POWER PLANT ENGINEERING

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Furniture Plant Uses Wood Refuse as Fuel

AT THE PLANT OF THE BERKEY & GAY FURNITURE CO., WOOD REFUSE FORMS SEVENTY PER CENT OF TOTAL FUEL SUPPLY

SOME THREE years ago when the Berkey & Gay Furniture Co., of Grand Rapids, Mich., decided to construct a new power plant they were confronted with the problem (not unusual in the case of industrial plants) of supplying the factory with power from the old power plant while the new one was being erected, and also of transferring the load to the new plant as soon as possible with the least possible loss in production due to interruption of the power supply.

At that time power was furnished by two old Corliss engines driving the factory machinery partly through direct-connected line shafting and partly through the agency of two 110-v. direct current generators. These generators were belted, one to each engine, and were connected in series, with a lead taken off from the center of the connection so as to form a 110-220-v., 3-wire system.

Steam was supplied by two boilers, one an old return tubular, and the other a regular Scotch marine type unit. This equipment was located in a part of the factory not far from the location of the present power plant. Figure 2 indicates its approximate location.

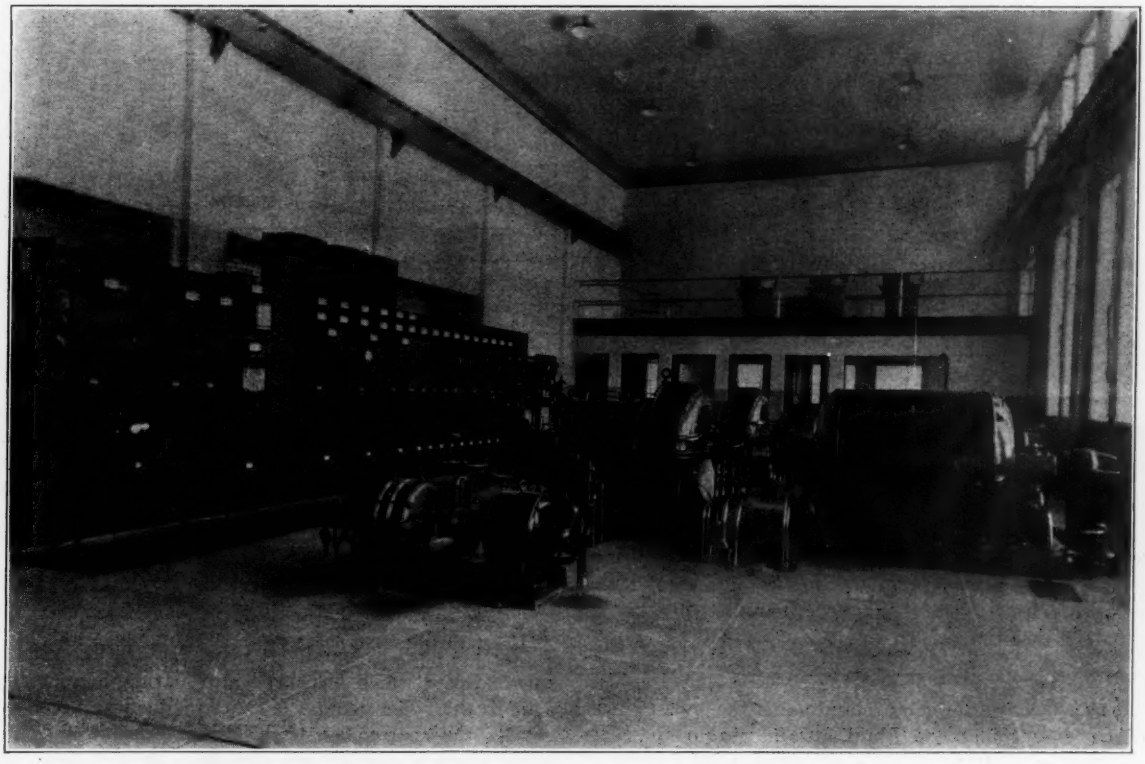


FIG. 1. THE TURBINE ROOM SHOWING THE TRANSFORMERS ON GALLERY ABOVE CHIEF ENGINEER'S OFFICE

By selecting an entirely new site for the new power plant, it was possible to operate the old plant without interruption while the new one was being built. Immediately upon the installation of the first turbo-alternator in the new plant, however, even before the floors were laid and before any of the finishing work was started, part of the load was transferred to the new turbine. At this time a corps of electricians invaded the factory and as rapidly as the work could be carried on, the existing

direct current motors were changed to alternating current units. New wiring was installed and in changing over it was merely necessary to take out a direct current motor, substitute an alternating current machine and connect it up to the newly installed alternating current wiring system.

In the meantime part of the mechanical load was still carried directly by the two Corliss engines previously referred to. One day, however, two large alternating current motors were installed adjacent to the engines,

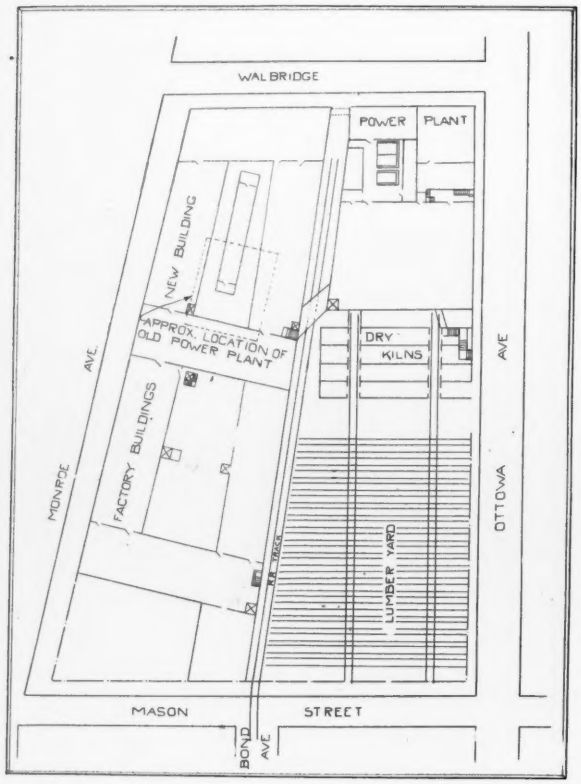


FIG. 2. PLAN SHOWING GENERAL ARRANGEMENT OF BUILDINGS

suitable pulleys placed on the line shafting and belts measured to length. When all preparations were complete, the engines were shut down, the belts removed, the new belts placed upon the motor pulleys and the motors started. They have been running practically ever since that time.

General Features

From an engineering standpoint the new power plant is exceptionally well laid out and the turbine room is as neat and attractive in appearance as any room of its type and size in the country. As may be noted from the accompanying photographs, the turbine room is finished entirely in white, the walls being of white enameled brick and the ceiling smooth plaster painted white.

At one end of the turbine room is located the chief engineer's office and the instrument room. The chief's office is attractive in appearance and arrangement and is furnished with modern office furniture in keeping with the dignity of the chief's position.

During the day no artificial illumination is required in any part of the turbine room, as an abundance of natural illumination is furnished through large windows at the side of the room. At night the room is lighted by 12 high powered incandescent lighting units hung from the ceiling and spaced uniformly so as to provide an equal distribution of light over the entire room.

While the equipment in the boiler room is efficient and of modern design, the design of this part of the plant is by no means on a par with the appearance of the turbine room. It is well laid out, however, and while it may be somewhat wanting insofar as appearance is concerned, it possesses a number of interesting features well worth describing.

Steam Generation

Steam for all purposes is produced at 150 lb. pressure in three 400-hp. Heine, standard longitudinal drum boilers arranged as shown in Fig. 4 with provision for one future unit. These boilers are provided

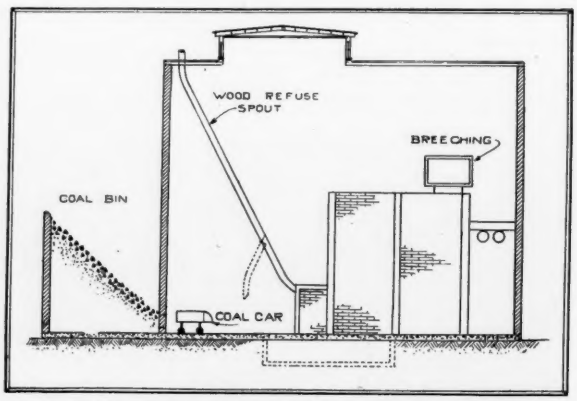


FIG. 3. WOOD REFUSE SPOUTS MAY BE DRAWN OUT OF WAY WHEN NOT IN USE

with Foster superheaters and are fired with both coal, and wood refuse from the factory.

Under ordinary conditions when the factory is operating at full force, the quantity of wood refuse burned under these boilers amounts to about 70 per cent of the total fuel used. This wood refuse is fed from an overhead bin through spouts directly into a type of dutch oven furnace as indicated diagrammatically in Fig. 3. When no wood refuse is available, the delivery spouts can be swung back out of the way as shown by the dotted lines.

Coal is fired by hand. It is delivered to the plant in railroad cars which discharge into a track hopper adjacent to the boiler room. A short inclined belt conveyor carries the coal to an 18 by 18-in. crusher and after being sized is carried into coal bins by a Webster coal conveyor. The latter, together with the crusher, is driven by a Westinghouse induction motor. From the coal bins the coal is shoveled into hand cars for further delivery into the boiler room.

Coal used under ordinary conditions is West Virginia coal with a heat value of approximately 14,000 B.t.u. per lb. It is not analyzed, but is bought on a basis of the evaporation of 1000 lb. of water; that is, the price paid for the coal depends directly upon the amount necessary to evaporate 1000 lb. of water under normal operating conditions.

City water is used for boiler feed purposes, but, due to the fact that all returns from the heating system, and from process work, as well as the condensate from the turbines, is also used for boiler feed purposes, only 4 per cent make up is required. All water to the boilers is metered, and as each car of coal is weighed before being fired, an accurate check is kept upon the evaporation. The latter runs about 8½ to 9 lb. of water per lb. of coal. An average boiler efficiency of 72 per cent is maintained.

City water which is used in the boilers is entirely free from encrusting solids and no trouble is experienced with scale; in fact, it is so free from scale-forming substances that trouble was at first encountered by the rusting of the interior of the boilers. This, however, has now been overcome.

These machines are described in detail as follows: No. 1 (referring to Fig. 6) consists of a size C-6, 295 hp., 3600 r.p.m., 150 lb. steam pressure, 75 deg. superheat, noncondensing, Kerr turbine, direct connected to a 480-v., 3-phase, 60-cycle Allis-Chalmers generator with direct connected exciter.

Nos. 2 and 3 are size 2D6E split type, Kerr turbines rated at 1065 hp. on 150 lb. pressure and 28 in. vacuum, coupled direct to 750-kw., 480-v. Allis-Chalmers generators with direct connected exciters.

No. 4 is a 25-hp. Kerr turbine direct connected to a Type E-90 Allis-Chalmers direct current generator rated at 15 kw.

Only one of the two 750-kw. turbines is used at one time, one being operated for a week while the other is shut down. Steam is bled from the intermediate stages

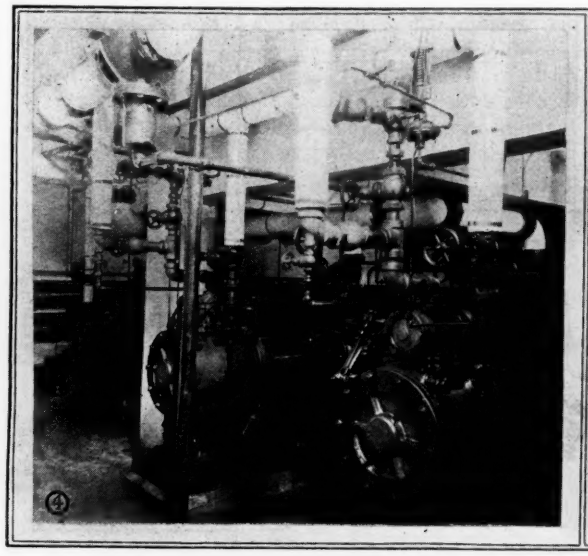


FIG. 4. A CORNER OF THE PUMP ROOM

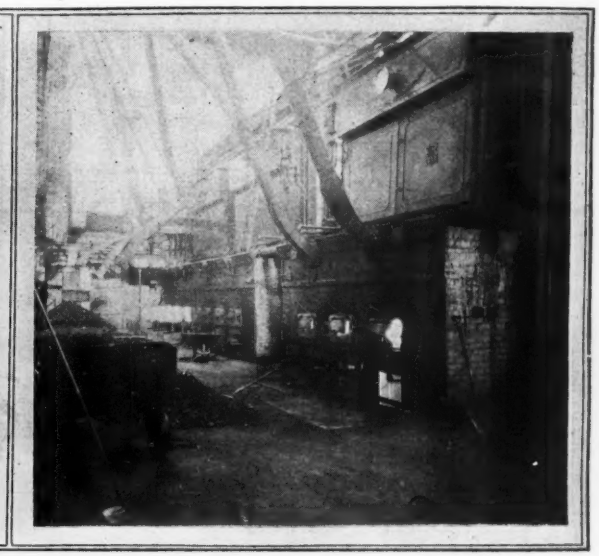


FIG. 5. THE FIRING AISLE IN THE BOILER ROOM

While no automatic ash handling system is provided at the present time, it is the intention of the management to install one, sometime in the future. At present, ash is removed from the ash pits by taking up the fish plates in front of the furnaces and shoveling it into ash cars.

Gases of combustion are removed from the boilers through a horizontal sheet steel breeching installed in the boiler room above the tops of the boilers and which discharges into the bore of a 175 ft. brick stack. The latter is 11 ft. in diameter at the bottom and 9 ft. at the top.

Generating Equipment

Electricity for power and lighting purposes is generated at 480 v. three-phase, alternating current by three turbo-generators, each consisting of a Kerr turbine and an Allis-Chalmers generator. One of these is a noncondensing unit, for use in carrying the night load in cold weather while the other two are large machines of equal capacity of the condensing, or bleeder type. A fourth, small unit is provided which may be used either as a spare exciter unit or to carry the lighting load at night during the summer when little or no exhaust steam is required.

of these machines at a pressure of about 2 lb. for use in the heating system and in process work in the factory. A considerable amount of exhaust steam is also used in heating the dry kilns of which there are sixteen.

Condensing Equipment

As only one of the main turbines is operated at one time, it was not necessary to install duplicate condensing equipment. One Worthington surface type condenser with a total surface of 1550 sq. ft., serves both generating units. Gate valves in the condenser piping system are arranged so that either or both turbines may exhaust into this condenser. This condenser, together with the various auxiliaries, is located in the pump room directly underneath the turbine room, as may be noted in Fig. 7.

Circulating water taken from the river about two blocks away and pumped through the condenser by a Worthington 10-CL-BS centrifugal circulating pump driven by a 15-hp. General Electric 220-v., 60-cycle induction motor. An 8 by 14 by 9-in. Worthington dry air pump of the flywheel type is provided and a small motor driven centrifugal pump removes the condensate.

Other pump room equipment consists of two boiler feed pumps, two vacuum pumps for the heating system,

the feed water heater, and two service pumps. The boiler feed pumps are American-Marsh pumps of the simplex type, as are also the vacuum pumps. The latter are fitted with Western Kieley Steam Specialty Co. pump governors. The service pumps referred to supply water for toilet and washing purposes and, like the feed and vacuum pumps, are also American-Marsh simplex pumps. Each service pump is provided with an air chamber for eliminating fluctuations in pressure.

Feed water to the boilers is heated to from 210 to 212 deg. F. by exhaust steam in a Warren Webster-Lea V-notch meter rated at 2400-hp. capacity. This heater is installed on a platform directly above the boiler feed pumps.

It is of standard General Electric construction throughout, being made of black, marine finish slate mounted on iron pipe supports and fastened to the wall at the rear by iron pipe tie rods. The main 3-phase bus bars are supported on 4-in. porcelain insulators installed on the tie rods. The bars are of 4-in. copper.

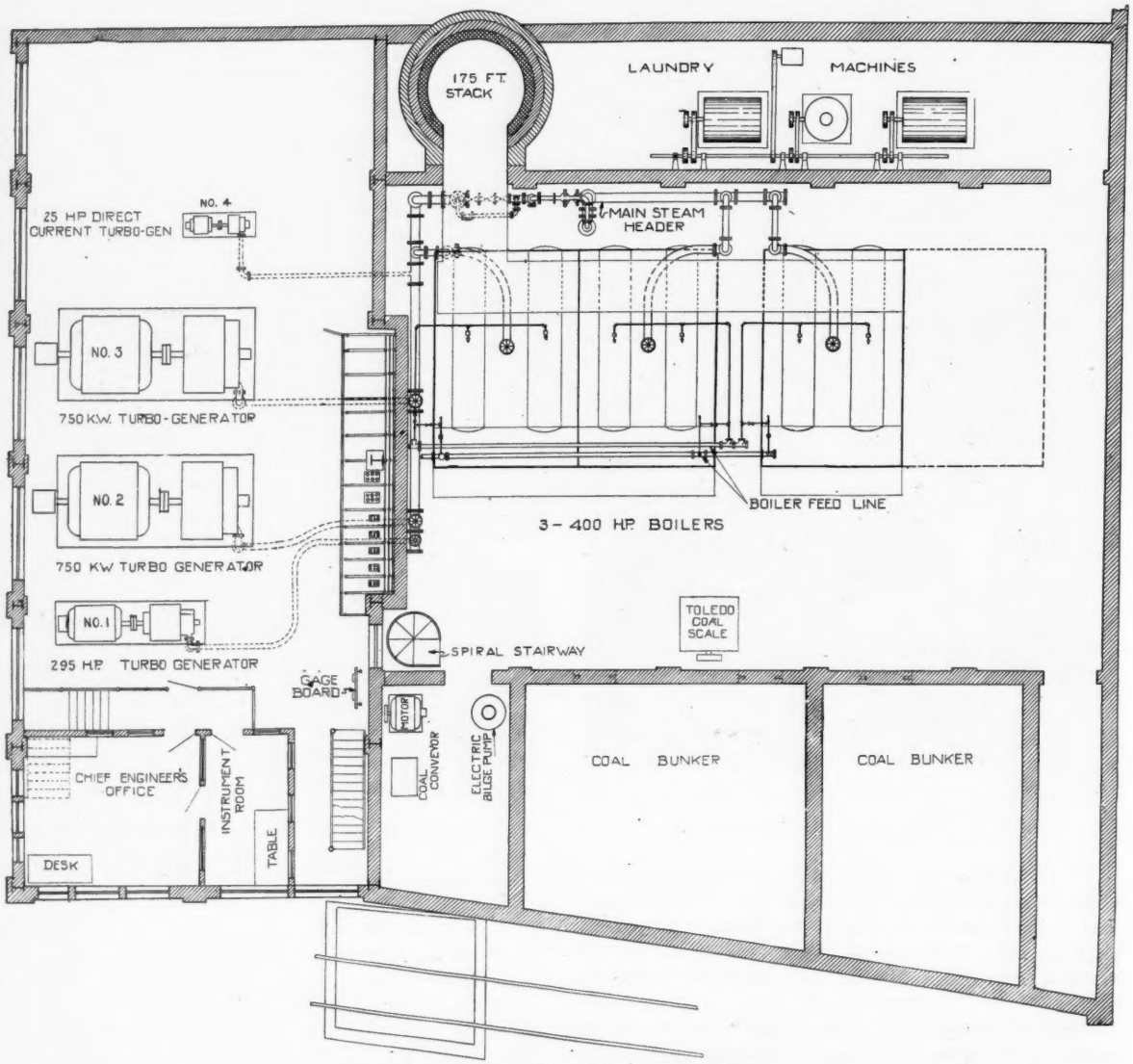


FIG. 6. GENERAL PLAN OF POWER PLANT

Electrical Features

Current for use in the plant and factory is generated at 480-v. and is controlled and distributed from the 14 panel switchboard in the turbine room. The latter is exceptionally well designed and is attractive in appearance.

Ample space is provided between the back of the board and the oil switches, and a wooden walkway is laid over the oil switch operating rods which are installed about 3 in. above the floor. The oil switches are supported from a vertical iron pipe framework and are all hand operated from the front of the switchboard through bell cranks and rods. The instrument transformers are installed immediately above the oil switches so as to simplify the wiring as much as possible. The Cutler Hammer field rheostats for the three alternating current generators are located above the respective generator panels and are hand operated through sprocket hand wheels and chains.

Viewing the switchboard from the front and taking the panels in order from left to right, the arrangement

is as follows: three exciter panels, each equipped with d.c. ammeters, rheostat, potential receptacles and 3 P. S. T. switches; one regulator panel on which is mounted a power factor indicator, a curve drawing voltmeter, a frequency meter, a voltage regulator and a polyphase watthour meter; one blank panel for future generator; three generator panels containing the usual ammeters, wattmeter, rheostats, field switches, and generator switches; one of these panels also contains a temperature indicator for the generator windings; five feeder panels, and one lighting panel.

For lighting and low voltage power service there are provided three 75-kv.a., 60-cycle General Electric transformers for stepping the 480-v. generator voltage down to 120/240 v. The secondary windings are connected to the outgoing circuits, single phase. These transformers are located on the gallery above the chief engineer's office and may be seen in the photograph, Fig. 1.

In the factory the electrical load amounts to about 1960 hp. in motors and a lighting load of 165 kw. There are 228 motors varying in size from three to one hundred horsepower and with the exception of two large synchronous motors are all induction motors. The two

Considered as a whole, this power plant is particularly well designed and is economical of operation. The factory which it serves employs about 1000 people and is devoted exclusively to the manufacture of household furniture. The factory building covers an entire city

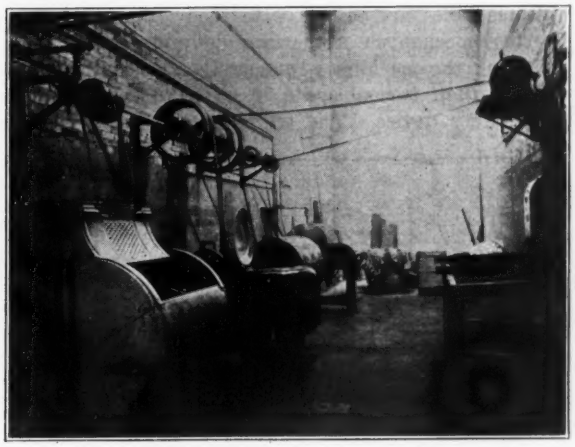


FIG. 9. LAUNDRY IN WHICH RAGS AND WASTE ARE RECLAIMED

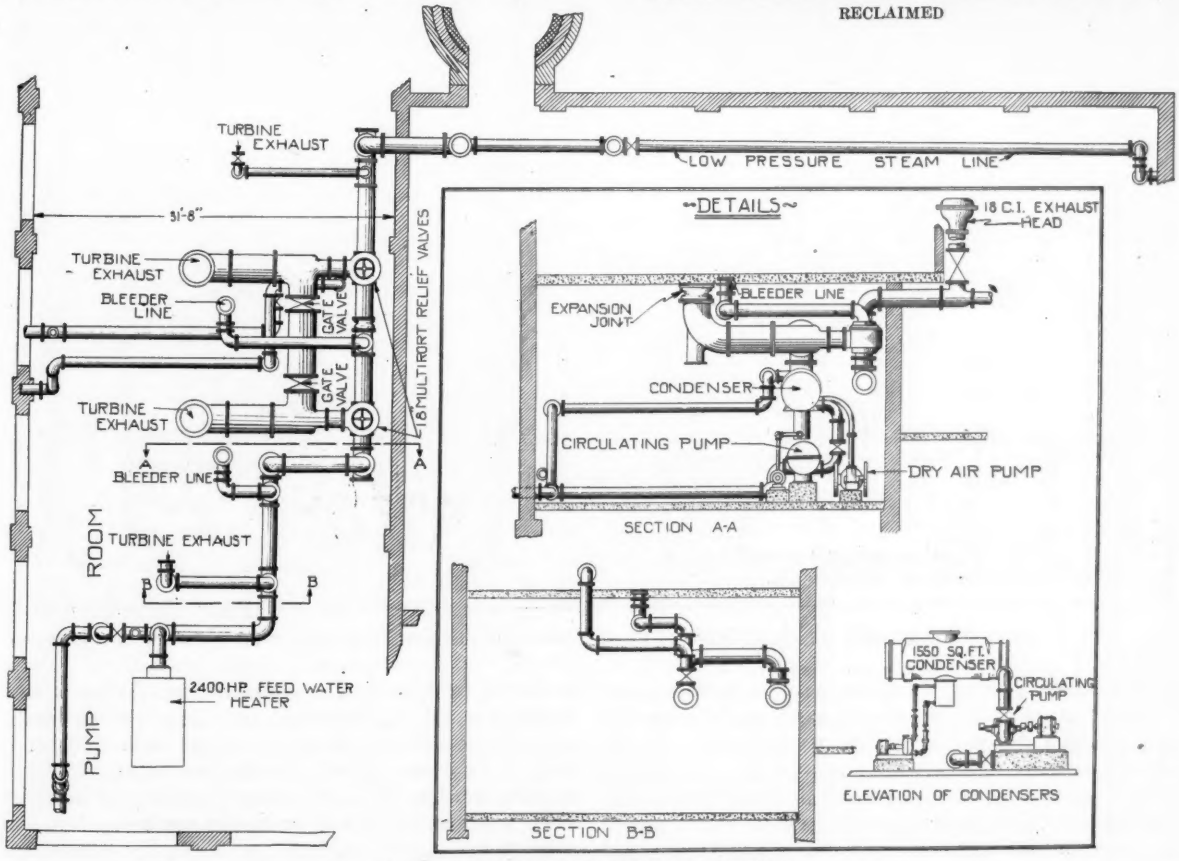


FIG. 7. LOW PRESSURE PIPING AND DETAILS

220-v. synchronous motors are used to drive blower fans and also to raise the power factor, which is usually maintained fairly high—about 85 to 88 per cent. One of the larger motors installed in the factory is used to drive a two-stage Ingersoll-Rand air compressor of 350 cu. ft. capacity. This air is used for various cleaning purposes in the factory.

block and the heating requirements in winter, alone demand a considerable amount of steam. The total heating load is approximately 70,000 sq. ft. Due to the fact that all the steam used in this heating system and also in heating the dry kilns, first has its mechanical energy extracted in the high pressure stages of the turbines, the overall economy of the plant is high.

There is an indirect heating system installed in some of the older factory buildings. This, however, is obsolete and at the present time is being replaced by a direct system of modern design.

In connection with the operation of the main turbines in the turbine room, it may be of interest to know that these machines are tested as to the workings of their governor mechanism at certain definite times. Once each week the machine is purposely allowed to run at a higher than normal speed in order to test the overspeed safety device. The tripping mechanism itself is is provided which automatically cuts off as soon as the main turbine and its attached oil pump comes up to speed.

Although not directly connected with the power plant, an interesting feature at the Berkey & Gay Furniture Co. is the reclamation of rags and waste used in the polishing department. These rags, usually well soaked with oil and dirt, were formerly burned under the boilers. The expense of these rags, however, was no small item and there is now installed a laundry where the rags and waste are washed. A view of this laundry

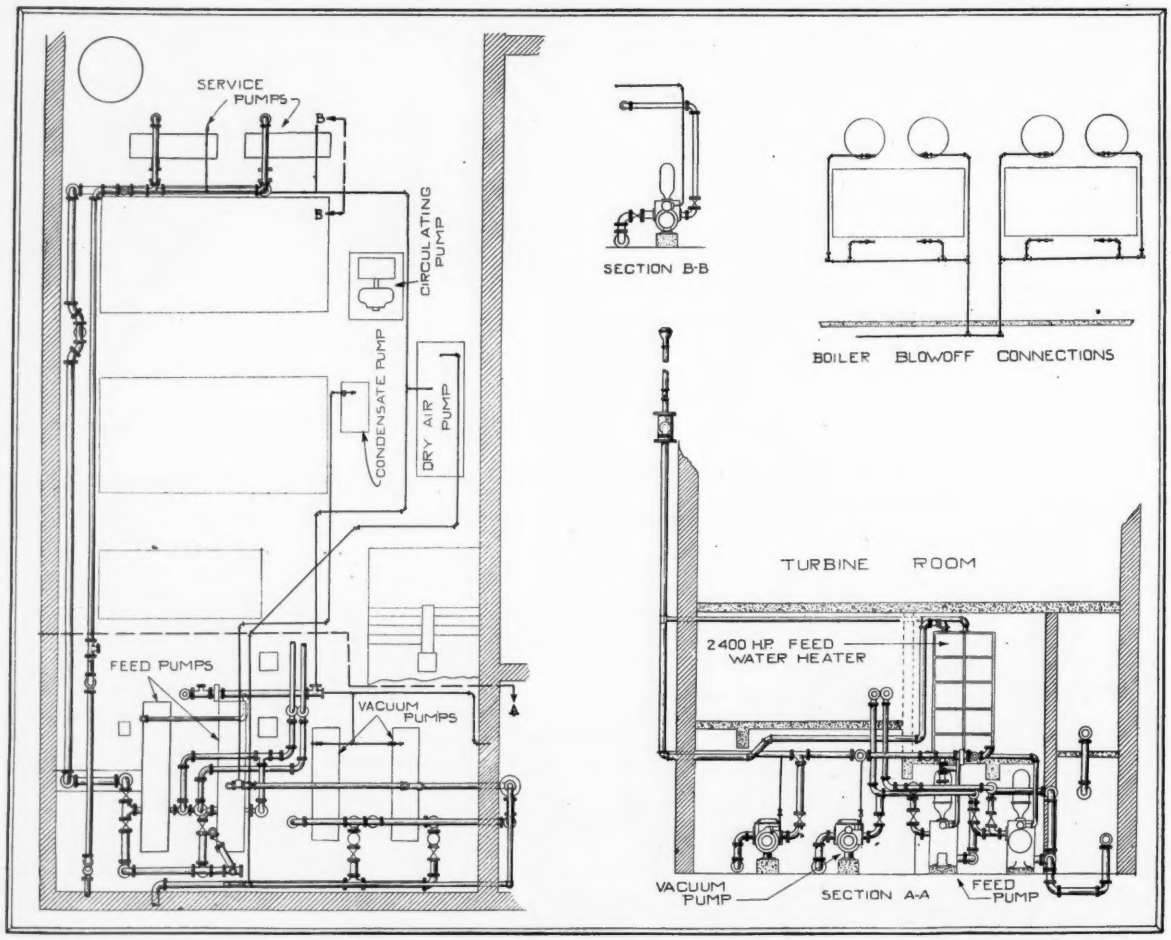


FIG. 8. GOOD ARRANGEMENT OF EQUIPMENT IN PUMP ROOM ENCOURAGES HIGH STANDARD OF MAINTENANCE

tried out each evening when the machine is shut down.

One feature which contributes much to the attractive and pleasing appearance of the turbine room, is the manner in which the turbines are finished. All exposed piping on, and to, these machines is nickel plated and polished. This, of course, greatly enhances the appearance and at the same time is easily kept clean and bright. Brass work as a rule requires much more polishing than does the nickel plating.

Oil is supplied to the turbine bearings by a force-feed pump driven from the main shaft. As the action of this oil pump is dependent upon the speed of the turbine, there can be no pumping action when the turbine is stopped. To supply oil, therefore, during the starting period a separate electrically driven centrifugal pump is shown in Fig. 9, the equipment consisting of two rotary washers, one for rags and the other for waste, and one centrifugal drier. A strong soda solution is used to take out the oil. It has been found that the expense involved in maintaining this laundry has been fully justified due to the savings in rag costs.

Conclusion

In concluding this description, we wish to express our indebtedness to Warren Townsend, Jr., chief engineer of the plant, for assistance extended in the gathering of data for this article, and to E. P. Rich, of Neiler & Rich, consulting engineers, Chicago, who designed the plant, for supplying drawings used in illustrating the article.

Pointers on the Inspection of Steam Turbines---II

INSPECTION OF PIPING AND ASSOCIATED EQUIPMENT AS IMPORTANT AS THAT OF MAIN TURBINE. BY JOHN T. WILLISON

ASIDE from the inspection of the turbine proper as discussed in a previous article, attention must, of course, also be given to the piping, the governor, the condenser and other auxiliary or associated equipment.

Steam piping to a turbine, does not, as a rule, need much attention. If erected correctly when installing the turbine so that no undue strains are set up, there is little to do beyond keeping the joints steam tight. It is wise, however, to check the piping over to see that the supports are properly carrying the weight and obstructions. Water is the turbine's deadly enemy and it is essential that the steam be dry if the turbine is to operate successfully. Foundations, whether of concrete, wood, or steel, also need inspection at intervals: any cracks in concrete or loose members of steel structure should be corrected at once, as vibration is sure to follow which will aggravate the existing evil still more.

Box shaped turbine bedplates resting on concrete foundations should have drains to carry off any water

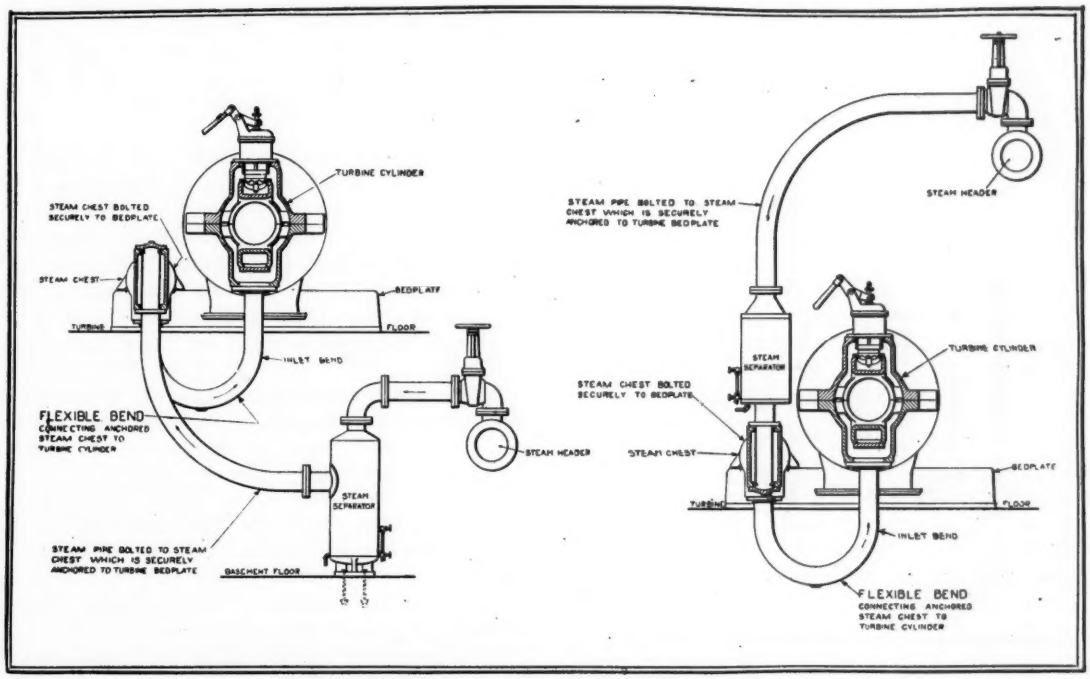


FIG. 1. GOOD EXAMPLES OF PIPING CONNECTIONS TO TURBINES

that the expansion is not causing distortion of the turbine.

Expansion joints in low pressure turbines, owing to their large size, sometimes cause trouble due to the collapsing of the expansion pipe; but this can be taken care of by inserting about four long bolts that project from one flange to within a short distance of the other. The exhaust piping on a condensing unit should be tested for air leakage or a serious loss of vacuum may result. A lighted torch or candle moved over the joints while under a vacuum will disclose any leakage. Strainers in the steam and exhaust lines should be periodically examined for corrosion which will in time weaken the plates until pieces break off and passing into the turbine cause damage to the rotor blades.

Separators installed in the steam lines, especially of exhaust or low pressure turbines, should have the baffles examined for corrosion and possible pieces ready to break off at some future time. All drains leading from the separator must be cleaned and cleared of all or oil which gets down into the bedplate to prevent the rotting of the foundations, or by ice if the turbine is in an exposed position and when no heat from the turbine is available.

BLADING

WHEN MAKING an overall inspection, the rotor shaft should be taken out and the rotors carefully scrutinized for loose wheels, broken or cracked buckets. Water passing through with the steam causes erosion of the buckets, and any buckets losing metal by this or other causes puts the delicately balanced rotor in a state of unbalance which will set up vibration that will in time make lots of trouble. Buckets whose contour has been changed through erosion or damage cause a loss of efficiency. An especially close inspection of the blading, the shrouding or lacing should be made for cracks which may cause some part to give way and in its passage through the remaining rotors do considerable damage. The nozzle blading should also have the same strict examination for the same reasons.

Governors

To inspect any of the many types of turbine governors intelligently it is first necessary to become familiar with the function of the several parts. On small turbines with the steam admission valve directly controlled by the governor, it is important that the valve moves freely and sets tight upon its seat. This can be tested by pulling out the governor weights and observing when the valve is seated. To test the tightness of the valve, the steam can be turned on and the governor blocked out until the valve seats itself. Any leakage past the valve can be seen from the turbine casing.

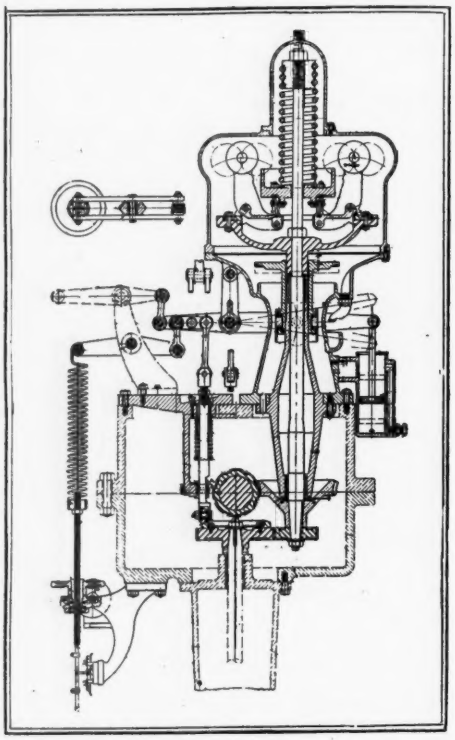


FIG. 2. TYPICAL STEAM TURBINE GOVERNOR

Valve stems are usually made as small as possible to prevent leakage and undue friction and great care should be exercised in handling the valve or the stem may get bent and will not then work freely. The valve stem should be examined for corrosion or roughness, hardness of the packing or for any reason that will prevent the free movement of the valve.

On large turbines where the governor operates a relay valve which in turn controls the regulating valve by means of a piston working in a cylinder under oil pressure, the inspection should cover the relay valve which should be taken out, the valve and all parts cleaned, the position of the working edges of the piston valve relative to the cylinder parts checked. The oil cylinder, piston and rod connected to the regulating valve should be cleaned of all grit, dirt, etc., the piston rod polished, packing replaced and the valve tested for leakage.

Most governors are equipped with an emergency overspeed device. This must be tested periodically to see that it functions correctly, which can be accomplished by running the turbine up to its normal speed. Have an assistant place a tachometer on the rotor shaft or the driven shaft to watch the speed, then by pressing down on the governor lever the speed will increase until the overspeed trips or the assistant signals that a predetermined safe overspeed is reached when the lever can be released and the speed again be under the control of the governor. As the overspeed did not cause the trip to work, adjustment can be made when the operation can be repeated until the governor works satisfactorily. When the operator is satisfied that the knockoff will work as desired, a further test can then be made by suddenly knocking off the load and letting the governor take care of the speed either by tripping of the overspeed latch or by bringing the turbine under the control of the governor until a normal condition is attained.

As in the aforementioned test, it is necessary to have an assistant with a tachometer to signal if the allowable percentage of overspeed is reached, when the operator can trip the governor by hand if it has not already acted.

If a governor overspeed trips while running under normal conditions, it is usually an indication that the governor is not controlling the speed. But this is not always so; excessive vibration sometimes causes the delicately poised latches and levers to disengage. In such a case, the trip can be hooked up again and if the same action occurs, the levers and latches can be adjusted to give a better hold until the cause is located and rectified.

When the governor is dismantled, the worm wheel and worm teeth, the spindle and bearings, the sliding sleeve, the pins through the governor weight arms, and the knife edges or cone points or whatever are the means of connecting the arms to the sliding sleeves should all receive very close attention. The portion of the spindle on which the sleeve slides should be polished. The knife edges or cone points which are hardened steel should be examined for rounded or chipped edges and either replaced or ground up to sharp edges again.

The overspeed latches, studs or levers must be in contact the very smallest amount to disengage easily and the bearing edges of these should be sharp or the vibration of the machine will easily knock them off and so stop the machine. The lubrication of the governor is important and all grooves and oil holes should be cleaned out and all set screws, collars, cotters, etc., checked over.

Condensers

If the turbine is condensing, the condenser and its equipment may now be inspected. If a surface condenser, the inside of the circulating water tubes can be seen by removing the heads.

Compressed air blown through the tubes separately and in a reverse direction to the flow of the water will in almost every case clear the tubes of all obstructions; failing this, a rod pushed through will do what is needed. Where the steam side of the tubes is coated with grease or other deposit, the condenser should be filled with water and a mixture of caustic soda and soda ash added and then the water boiled for several hours. This invariably removes all dirt from the tube surfaces.

To locate leaking tubes, fill the condenser casing with air; a low pressure will do. Pass a lighted candle over the ends of the tubes, then by observing the flame the leaking air will easily show the defective tubes. A test the writer finds effective to determine whether there are any tubes leaking without removing the heads is to run the circulating water through the tubes when the rising water in the hotwell will denote a leakage. A vacuum created in the condenser casing will give approximately working conditions and greatly help in finding whether any leakage is present.

Where turbines are connected to jet condensers by a short pipe or where installed with the exhaust pipe rising to a surface condenser set on the same floor level, they are generally equipped with float operated vacuum breakers that prevents flooding of the turbine if the condensate pump stops. As this is a likely possibility, frequent tests of this equipment are necessary to ensure that the breaker is free and does not stick. To test this, a simple method is to fill up the condenser to a level high enough to raise the float and so open the vacuum breaker if all is in order. If the breaker does not operate in the event of the condensate pump stopping, there is danger of the water flooding back into the turbine casing which may result in a twisted shaft, broken wheel or otherwise a wrecking of the turbine.

Modern installations have separate centrifugal condensate pumps and air ejectors. The centrifugal pumps should be taken apart about every 6 mo. and their impellers examined for the amount of clearance and damaged vanes. Where the shafts are fitted with bronze sleeves that run in the packing, these should be renewed if worn. Stuffing-boxes are generally water sealed; a hollow brass cage between the shaft packing is used to allow the sealing water to flow around the shaft. In pulling up the glands this ring is pushed beyond the water inlet and the flow of the sealing water is stopped. This point should be watched when the old packing is in and also when renewing the packing. In an air pump of the plunger type, the discharge valves should be examined and changed if badly worn, the piston rod packing and all joints tested for air leakage and repacked if necessary.

In air ejectors of the Radojet type, there is little to be done except ensuring that the strainer in the steam line has not allowed bits of packing, rubber, etc., to pass through and lodge in the nozzles and small passages, or perhaps a little adjustment of the steam nozzles is necessary. It is very important that all parts which are likely to produce a poor vacuum should be fixed in good shape, as a low vacuum on a condensing turbine means considerable loss of power.

Operating Characteristics of Flash Evaporators

High and Low Pressure and Single and Multiple Effect Evaporators Are Compared. By John Forbes*

ESSENTIALLY a single effect evaporator system for supplying pure boiler feed make-up consists of a closed vessel or evaporator in which the raw water is evaporated, and a distiller into which the vapor generated in the evaporator is discharged and in which it is condensed in tubes surrounded by cold circulating water. A double effect evaporator is a single effect system with the addition of a second evaporator chamber. The vapor produced in the first chamber or effect is utilized as the heating medium in the second evaporator chamber or effect. Only the vapor produced in the second or last effect is led to the distiller and condensed, that produced in the first effect being condensed in the heating space of the second effect.

Similarly, a multiple effect evaporator consists of any number of evaporator effects greater than one, and its operation is precisely similar to that of the double effect evaporator. The vapor generated in one effect is used as the heating medium in a subsequent effect, wherein it surrenders its heat and is condensed. The vapor produced in the last effect is discharged into the distiller. The accompanying table gives approximately the quantity of water evaporated per pound of steam supplied for one or more effects.

From this table it may be seen that the evaporator efficiency increases with the number of effects. This increase in efficiency, however, applies to the evaporator system exclusively. It does not hold true for the steam power plant as a whole. As a matter of fact, the overall efficiency of the whole plant is independent of the number of effects in the evaporator system.

*Engineer, Schutte & Koerting Co.

In order to evaporate the raw water, it is necessary for heat to flow from the heating medium, for example, steam in the coils of an evaporator utilizing heating coils, through the coil walls or heating surface, into the raw water. This heat flow cannot, of course, take place unless the temperature of the heating steam is higher than that of the raw water. With ordinary working limits, the heat thus transferred varies directly with the temperature difference between the steam and the water. The greater this difference, the greater the amount of water evaporated, and the less the heating surface required in order to produce a given amount of vapor. From this it may be seen that for a multiple effect evaporating system in which the steam temperature in the first effect is the same as the steam temperature in a single effect evaporator, and in which the vapor temperature in the last multiple effect is the same as that in the single effect evaporator, the net heat transferred from the heating to the absorbing medium is the same as in the single effect. In the multiple effect evaporator the heat flow is subdivided into stages; but since the heating surface of each multiple effect unit is the same as the heating surface of the single effect unit, the total heat flow in both cases is the same.

WATER EVAPORATED IN SINGLE AND MULTIPLE EFFECT EVAPORATORS

Number of effects..	1	2	3	4	5	6
Water evaporated per lb. steam-lb..	0.914	1.788	2.623	3.417	4.167	4.800

As the number of effects is increased, the cost of the apparatus is likewise increased, and this increase in cost is frequently the determining factor in selecting the number of effects. A multiple effect evaporator is ordinarily used in all instances where the vapor from an equivalent single effect evaporator cannot be absorbed by the boiler feed water in the boiler feed heater.

Low Pressure and High Pressure Evaporators

For purposes of comparison, a low pressure evaporating system is one in which the raw water is vaporized at comparatively low pressure and temperatures.

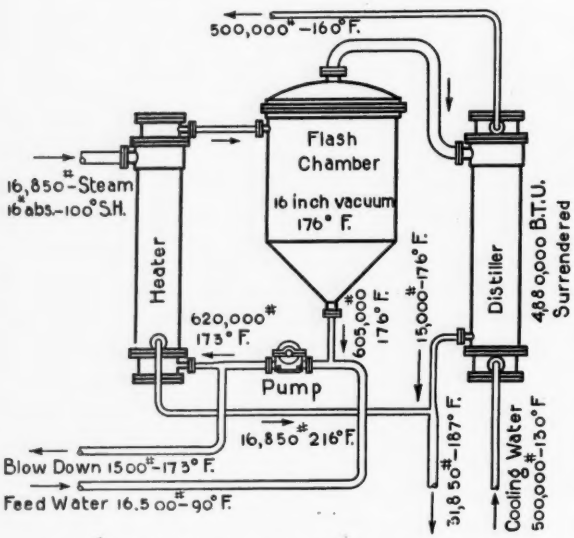


FIG. 1. THERMAL CYCLE OF SINGLE EFFECT FLASH EVAPORATOR

If the pressure or the temperature is relatively high, the system is known as a high pressure evaporator system.

High pressure evaporating systems are operated with live boiler steam either at full or reduced pressure, and low pressure systems use auxiliary exhaust steam at about 2 lb. gage pressure.

In evaporator plants running on auxiliary exhaust steam, the vapor produced is maintained at a vacuum. Such systems are ordinarily installed to advantage where there is a large amount of exhaust steam available, and also in instances where it is desirable to supply an economizer for a low temperature boiler feed heater.

High pressure evaporating systems using boiler steam either at full or reduced pressure can be profitably installed where the make-up requirements are small and where the amount of exhaust steam available is likewise small.

If, however, such an evaporator were operating single effect, and supplying a make-up equal to 5 per cent of the total boiler evaporation, it would consume approximately 5 per cent of the total boiler steam. Under these conditions practically 5 per cent of the total boiler output, and, therefore, of the coal bill, would be charged against the evaporator—a charge which would, under most plant operating conditions, be prohibitive. A multiple effect evaporator would partially offset the losses of the single effect unit.

A single effect high pressure evaporator running on boiler steam can be most economically run when the auxiliaries are electric driven, there being no exhaust steam available for feed water heating in this case and when the make-up water is not over 10 per cent of the total boiler evaporation. If the make-up is less than 5 per cent, then some of the auxiliaries may be steam driven. Under these conditions, condensed steam from the evaporator is piped directly to the open boiler feed heater, and the vapor is likewise passed to the heater where it is absorbed by the condensate from the main power plant condenser, the entire resulting mixture being the amount of boiler feed water that is required.

If the amount of make-up water required is so large that the vapor cannot all be condensed in the boiler feed heater, or if, on the other hand, the amount of auxiliary exhaust steam available in the plant is so great that it likewise cannot be absorbed in the boiler feed heater, then a single effect evaporator cannot be chosen to supply the pure boiler feed make-up. A multiple effect evaporator is necessary, and of such a capacity that the total available exhaust steam in the plant plus the vapor from the last effect of the evaporator can just be absorbed by the boiler feed water heater. Thus the heat supplied by the exhaust steam and the vapor is just sufficient to raise all of the boiler feed to the proper temperature.

Non-Scaling Flash Evaporator

Schematic drawings showing the thermal cycle of the working substance of a recently developed low pressure non-scaling flash evaporator are given in Figs. 1 and 2 for single and double effects respectively. Essentially the flash evaporator consists of a heater, a flash chamber, a distiller or condenser, a circulating pump, a vacuum pump and the necessary piping.

Cold raw water from the source of supply is forced by means of the circulating pump through the make-up water piping and the automatic feed control valve and discharged into the heater where it is heated under pressure by auxiliary exhaust steam to about 169 deg. F. From there the hot raw water is discharged into the flash chamber in which a vacuum of about 25 in. is maintained by the vacuum pump.

Internal structure of the flash chamber is arranged to subdivide the incoming water into a multitude of thin films. The hot raw water, as it enters the flash chamber, is at a temperature, let us assume, of 169 deg. F. The boiling point corresponding to the vacuum maintained in the flash chamber is 131 deg. F. Consequently, since the water is at a temperature above its boiling point, it boils spontaneously and explosively. This phenomenon is known as flashing. A part of the water is vaporized at the expense of the intrinsic heat of the raw water.

As quickly as the vapor is formed, it is drawn into the distilling condenser by means of the vacuum created therein by the vacuum pump. The latent heat of the vapor is absorbed by the cold circulating water and the vapor is condensed. The evaporator make-up is frequently supplied by a part of the warm circulating water that is discharged from the distiller.

Condensed vapor or distillate is either returned to the boiler or else discharged to the boiler feed water heater. The flash evaporator not only provides the neces-

sary pure distilled boiler make-up water, but it also supplies this water free from dissolved and entrained air and carbon dioxide, hence corrosion of boiler tubes, piping, economizer tubes, etc., is eliminated.

Liquid not evaporated is withdrawn from the flash chamber, mixed with the incoming evaporator make-up water, and recirculated. A part of this liquid is continuously blown off at the discharge of the circulating pump. This continuous blowoff keeps down the concentration of the scale forming impurities.

Exhaust steam from the several pumps is all used in the heater to raise the temperature of the raw water. If the steam is insufficient for this purpose, additional auxiliary exhaust steam is admitted through the heater inlet opening.

In plants where a surface condenser is operated together with the evaporating system, the vapor from

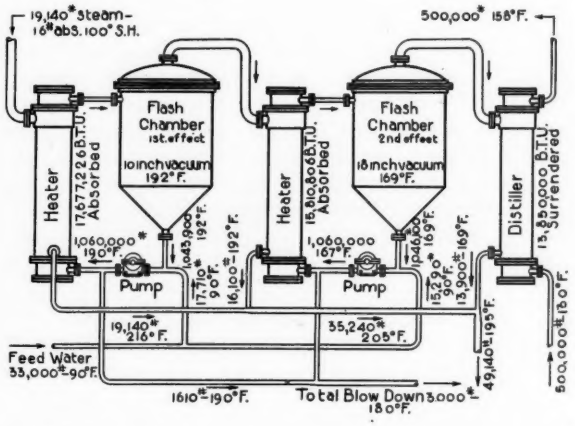


FIG. 2. THERMAL CYCLE OF DOUBLE EFFECT EVAPORATOR

the evaporator may be piped directly to the main surface condensing unit and thence passed, together with the turbine condensate, to the boiler feed heater.

This type evaporator wastes practically none of the available heat supplied by the exhaust steam. The only heat that is lost is the small amount in the blowoff and in radiation. For this reason, the thermal efficiency of the evaporator is almost 100 per cent. Auxiliaries are simple and durable in construction, require only a minimum of attention, and little or no expense for operation and upkeep. The distilling condenser may be either of the surface condenser or jet condenser type. Either kind can be used. The surface condensing distiller is installed wherever it is necessary to keep the main condenser condensate, when it is used as the circulating water of the distiller, separate from the distillate; or where it is intended to use as the distiller circulating water, the raw water evaporator feed instead of the main condenser condensate. By the use of a surface condenser distiller and an air pump, air and non-condensible gases are effectively removed from the distillate space of the condenser, thus the distilled water is thoroughly degasified.

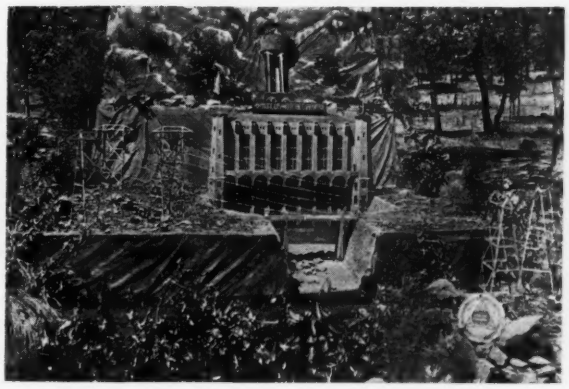
Jet condensing distillers are less expensive, give a closer terminal difference, and consequently a greater evaporator capacity under given conditions. Both the distillate and the main condensate are deaerated, whereas in a surface distiller only the distillate is purified in this way. By mixing the main condensate and the distiller water, one additional pipe line from the distiller to the storage tank or feed water heater is avoided. The flash evaporator generates vapor under a vacuum, that is, under conditions of relatively low temperatures. Hence the possibility of scale formation in the evaporator is reduced to a minimum inasmuch as the quantity of scale formed is directly proportional to the temperature of evaporation.

Absence of scale and of the customary evaporator coils is one of the reasons why the flash evaporator is able to maintain its capacity for practically indefinite periods of time. The importance of this advantage can be more clearly appreciated if the amount of solids that are ordinarily held in solution and that in other types of evaporators are deposited as scale on evaporator tubes is calculated by means of the following equation: Solids, in lb. per day, = solids in grains per gal. of raw water $\times$ raw water in lb. per hr. $\times$ 34 $\sqrt{}$ 8.3 $\div$ 7000.

Although all of the solids do not actually separate from the solution, the equation, nevertheless, shows the importance of eliminating scale formation and mechanical cleaning. This is effectively accomplished by the flash evaporator wherein evaporation takes place at temperatures too low for scale to form. About 4 per cent of the total evaporator feed is a sufficient blowoff for fresh water of fair quality.

Evaporator blow-down losses are smallest when evaporation takes place under a vacuum. This is so because the temperature of the blowoff discharge is lowest under vacuum evaporation. Furthermore the amount of blow-down is much less than is necessary at high operating temperatures, because at high temperatures there is considerable scale accumulation and priming, necessitating a relatively large amount of blow-down. This flash evaporator is fitted with automatic devices for maintaining constant predetermined rates of evaporator feed and blow-down.

Miniature Model of Power Plant



This miniature model of Pit River power plant No. 1, which is being exhibited in California by the Pacific Gas & Electric Co., shows the tree-clad hillside of Pit River Camp, the steel pipe lines, the power house and outgoing transmission line and tiny copper cable supported on diminutive steel towers. Real water courses through the power house from which it surges forth into Pit River. The realistic effect is heightened by sparks of blue flame discharged from the cables to the transmission lines which are charged with high frequency currents.

Deflecting Arches for Chain Grate Stokers

CERTAIN TYPES OF ARCHES INSTALLED AT REAR OF FURNACE HAVE BEEN FOUND EFFECTIVE IN BETTERING COMBUSTION CONDITIONS. BY HENRY WEAVER

DUE in one respect to the demand for higher efficiencies in burning the smaller sizes of coal, especially the anthracite coals of high ash content, the chain grate type of stoker is coming into more popular use.

One objection to some furnace and grate settings is the spraying of the finer and lighter particles of coal into the ash pit, and the carrying of solid matter up into the breeching and stack by the high draft velocity which is obtained when running under forced draft at moderate to high ratings.

This condition has been greatly remedied in our plant by the installation of a back arch as shown in Fig. 1. This arch is made as follows: Set I beam as

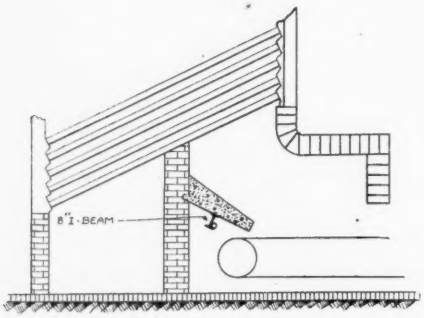


FIG. 1. IN THIS ARCH THE I BEAM CENTER IS PLACED 18 IN. ABOVE THE GRATE AND 18 IN. FROM BRIDGE WALL

noted in the drawing and place 42-in. regular old-fashioned grate bars upside down, tying into bridge wall about 6 in. and leaving center rest on eye beams. These bars are set 10 in. apart. Next build form underneath and prepare a mixture of high temperature cement and granulated fire brick. Take old fire brickbats which are free from clinker and mix with cement and granulated brick and fill in around the iron until the arch is about 8 in. thick in front and 14 in. thick in back.

This part of the job being completed, a pipe in which a number of small holes have been drilled is placed on the front of the I-beam, as shown, with the holes facing towards the I-beam at an angle of about 80 deg. to the horizontal. This pipe is connected to an air duct.

In our case it was found that this pipe was unnecessary as the arch remained sufficiently cool without it, but in cases where the draft balance is liable to become positive, its installation is to be recommended.

This arch serves not only to help prevent the coal from being thrown into the ash pit, but also diverts the cold stream of air which ordinarily flows up the bridge wall into the tubes without coming into the high temperature zone. This air is necessary to keep the exposed parts of the grate from being affected by the high temperature, and in being diverted over the high temperature zone where combustion is taking place is available for combination with any CO which may be present, to form CO_2, thus making the regulation of the flue gases easier to handle and maintain a higher CO_2 content.

At first the writer considered the installation of a suspended arch as shown in Fig. 2 but the idea was rejected for various reasons, principal among which was the fact that the draft area below the bottom of the first pass was obstructed so as to cut down the available capacity of the furnace. Another objection was that in case the draft was intense enough to satisfy the highest capacity desired, the infiltration of cold air into the passes of the boiler and the consequent losses would be considerable.

Before installing the back arch, the combustible content of the ash averaged about 35 per cent but after its installation the combustible was found to average only 17 per cent.

There was also an improvement in the CO_2 content and the total saving in our plant was about 150 T. of coal per month out of a total of 1400 T., or approximately 11 per cent. The physical condition of fire was greatly improved, as the reverse current of air, coming under back arch, caused a whirly action which redeposited the sprayed coal back on the grate and also gave a better mixture as the cold air came into positive contact with the gases. Furthermore, it built up a slightly higher furnace pressure in the front over the

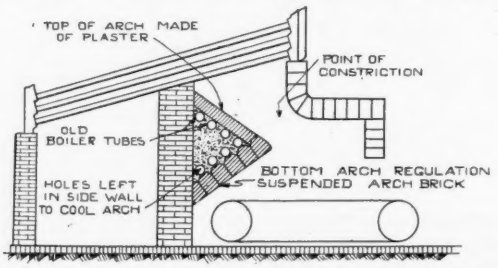

TOP OF ARCH MADE OF PLASTER
POINT OF CONSTRICTION
OLD BOILER TUBES
HOLES LEFT IN SIDE WALL TO COOL ARCH
BOTTOM ARCH REGULATION
SUSPENDED ARCH BRICK

FIG. 2. TYPE OF SUSPENDED ARCH WHICH WAS FIRST CONSIDERED

first pass and has cut the risk of losing the ignition down so that the firemen say you can hardly put the fire out.

This arch as constructed is standing up very satisfactorily under our furnace conditions. The draft over the fire is carried about 0.03 in. and no serious faults have developed as yet after a run of 6 mo. and carrying a load as high as 200 per cent rating at times, the air passing under the exposed iron being sufficient to keep it cool.

If a closer balance in the furnace is desired, it is recommended that a pipe be suspended on the I-beam in the manner shown in Fig. 3, with one end sealed up and the other end connected to the air duct. Drill holes in the pipe about 12 in. apart and mount it so as to direct the air against the iron at an angle of about 60 deg. to the horizontal. The amount of air can be regulated by a damper in this pipe and can be compensated for in the furnace gases by slightly cutting down the amount through the fire so as to form CO which will unite with this air and form CO_2.

The carrying of fine particles of coal in the gases also gave us much trouble, and while the arch helped

matters in this respect, it did not remedy this condition. The boilers had horizontal baffles and the deposit lying on the baffles would be blown against the tubes by the soot blowers, and being of an abrasive nature soon cut holes in the tubes. After renewing quite a few tubes, we took the horizontal baffles out and put in inclined baffles with an angularity of about 30 deg. to the perpendicular, and since then have had no more trouble of this kind.

In the breeching and stack the amount deposited also gave us much concern until we tested this material and found that it had a fuel value of about 10,000 B.t.u. as against 12,500 B.t.u. in the original coal.

After obtaining this information we installed a chute from the base of the stack, which in this case

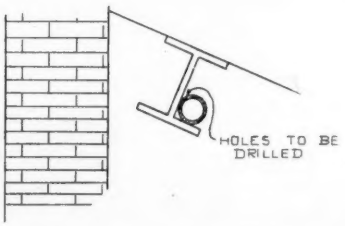


FIG. 3. PERFORATED TYPE INSTALLED ON I BEAM GIVES CLOSE REGULATION

was of sufficient elevation, and when putting coal in overhead bunker would mix it together. The deposit in the combustion chamber, while being much finer, was also tested and found to be burnable. This was also mixed with the fresh coal.

Errors Introduced in Indicator Cards by Use of Cotton Cord

TESTS MADE AT UNIVERSITY OF OKLAHOMA PROVE UNSUITABILITY OF COTTON CORD FOR TAKING INDICATOR DIAGRAMS. BY EARL BARTHOLOMEW

THOSE WHO have occasion to use engine indicators from time to time and who have used various kinds of cord for imparting motion to the drum, will probably be interested in a series of tests conducted at the University of Oklahoma. These tests were run to determine the amount of the error when cotton and steel strings are used to actuate the drum and how this error varies with the speed.

METHOD OF TESTING

FOR THESE tests a double-ported, balanced valve, 20-hp. steam engine and an indicator made by a well-known concern, were used. A prony brake was used to keep a constant load on the engine.

One series of tests was run using cotton indicator cord for moving the drum. The speed was varied from 285 down to 125 r.p.m. Before each card was taken, the engine was set on head-end dead center and the throttle was opened, allowing the pencil point to trace a vertical line. The same was done for the crank end. The engine was then allowed to run at the desired speed and both a head end and a crank end card were taken on the same piece of paper.

Cards under the same conditions were taken, using guitar string wire for moving the indicator drum. The results are shown in the accompanying table and figures.

TABLE SHOWING RESULTS OF TESTS ON INDICATOR CARDS

Card No.	End	R.P.M.	Avg. Card Ht.	Per Cent Error in Card Ht.	Card Length	Per Cent Error in Card Length	Dist. Between Erected End Pts.	Per Cent Error in Distance Between Erected End Pts.	Kind of Cord
6	H	285	.383	5.43	2.78	4.14	2.66	8.28	String
6	C	285	.379	4.54	2.78	4.14	2.66	8.28	String
8	H	282	.405	0.0	2.9	0.0	2.9	0.0	Wire
8	C	282	.397	0.0	2.9	0.0	2.9	0.0	Wire
7	H	218	.383	6.34	2.76	4.82	2.65	8.61	String
7	C	218	.373	4.85	2.76	4.82	2.65	8.61	String
9	H	216	.410	0.0	2.9	0.0	2.9	0.0	Wire
9	C	216	.392	0.0	2.9	0.0	2.9	0.0	Wire
4	H	125	.404	.2	2.7	6.88	2.62	9.64	String
4	C	125	.385	4.45	2.7	6.88	2.62	9.64	String
10	H	125	.403	0.0	2.9	0.0	2.9	0.0	Wire
10	C	125	.403	0.0	2.9	0.0	2.9	0.0	Wire

Maximum Tension in Cord 5#
Minimum Tension in Cord 1 3/4#

Cotton String Used - Standard cotton indicator cord
Wire Used - Heavy Guitar String Wire

This table shows information about representative cards that were taken during the test.

In the experiments, the actual travel of the reducing motion on the engine was 2.9 in. It will be seen

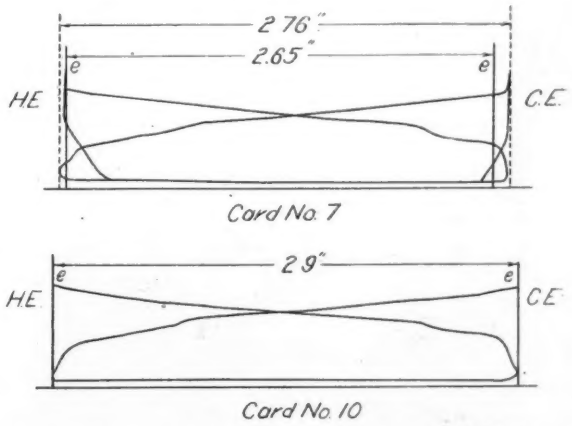


FIG. 1. TWO CARDS SHOWING DIFFERENCE IN LENGTH PRODUCED BY THE USE OF STRING AND WIRE

that the distance between the end lines e, e, erected while the engine was on dead center, was 2.9 in. when wire was used, but that the distance was only about 2.65 in. when cotton cord was used, this difference being due to the stretch of the cord. The amount of the error in this case amounted to 8.6 per cent. The length of the cards taken was greater than the distance between the erected end lines due to the inertia of the drum. It will be noted that the length of the cards taken when wire was used checked the actual travel of the reducing motion. In some cases the cards taken when string was used were 6.88 per cent too short.

Cards taken under the same conditions, using string and wire, were integrated and divided by the actual length. By reference to column 5 in the table, it will be seen that error in mean effective pressure due to the combined stretching and inertia effect, in some cases, amounts to over 6 per cent.

Curves shown in Fig. 2 show the variation of error due to the speed of the engine. It is not claimed that

the error in every case varies as it did in this case, because differences in the tension of the cord would affect the error due to inertia and stretching of the cord. The most outstanding result of the test is the proof that

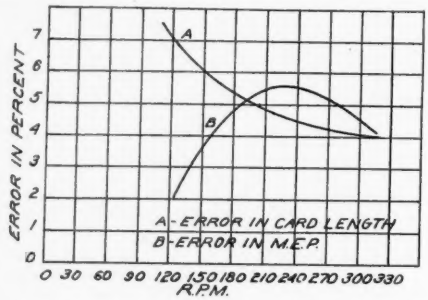


FIG. 2. CURVES SHOWING THE EFFECT OF SPEED UPON THE ERROR DUE TO CORD

cotton cord is very unreliable and erratic as a cord for actuating the drum and that it should be replaced by flexible steel wire.

Good Engineering Characterizes New Steam Plant

WHEN A FIRE destroyed the electric light plant at Abilene, Texas, in the spring of 1919, the Abilene Gas and Electric Co. immediately took steps to build a new ice and electric plant which would typify

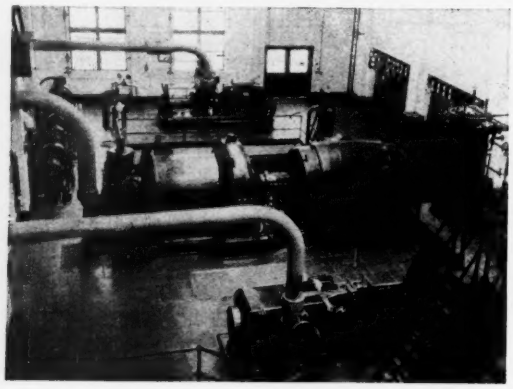


FIG. 1. THE ATTRACTIVE APPEARANCE OF THIS TURBINE ROOM PROMOTES EFFICIENCY

the best in modern developments in power house construction. Plans were drawn and ground was broken for the new plant on December 23, 1919. This plant was formally opened on Oct. 25, 1922, and is now in operation.

This plant, in which is combined an ice plant and an electric generating station, is located about three-quarters of a mile from the center of Abilene. The electric station serves the City of Abilene and 27 other communities by a system of high tension transmission lines extending in the four directions, and comprising a total of 286 sq. mi. in all. At the present time the company has 8600 customers, and work has been started on an extension that will serve three more towns and will add 700 customers. The connected load is about 10,000 kw., about equally divided between lighting and power. The peak loads average 2000 kw. and the average daily output from the station is 27,000 kw.-hr. The territory served is building rapidly and many lighting and power consumers are being connected. Among the power consumers are two plaster mills, six city pumping plants, one street railway system, five cotton gins, and several flour mills, ice plants, grain elevators, etc.

Railroad facilities are provided by the Abilene & Northern Railroad and the Texas & Pacific Railroad.

FIG. 2. SMOKE AND DIRT IS CONSPICUOUSLY ABSENT IN THE VICINITY OF THIS POWER PLANT

There is a railroad siding from the Abilene & Northern Railroad running onto the property and the Texas & Pacific Railroad has a spur of track alongside of the property, with which the ice plant is connected by a conveyer for loading ice into cars. The plant is located on a 14-acre tract and the building is 195 ft. by 115 ft. with a little more than half of the floor space devoted to the ice plant. The building is of reinforced concrete and hollow tile construction and is fireproof throughout.

Generating Equipment

ELECTRICAL GENERATING equipment consists of two units, the first being a Westinghouse 2500-kv.a. turbine-generator with a direct connected exciter, the electrical characteristics of the unit being three phase, 60 cycles, and 2400 v. at 3600 r.p.m. The steam conditions are 200 lb., 150 deg. superheat and 28 in. vacuum. A Westinghouse condenser with a surface of 4500 sq. ft. is provided. Air and hot-well pumps are Westinghouse, turbine driven and a motor-driven circulating water pump is provided.

Unit No. 2 is a General Electric 1250 kv.a. turbine-alternator with the exciter independent and motor-driven. The auxiliaries of this unit are a 3000-sq. ft. condenser made by the Wheeler Condenser and Engineering Co., a motor-driven hot-well pump, a motor-driven centrifugal pump, and a steam jet air pump of the two-stage type.

Circulating water is handled by 65 spray nozzles arranged in clusters of five each. A booster pump is

used in connection with the sprays. A pond was formed by installing a dam in a creek known as Cedar Creek and the excavation of intake and discharge flumes leading to an intake crib.

As a reserve unit a steam-driven General Electric exciter is provided. A 75-kw. motor-driven d.c. generator furnishes current for the local traction company.

Current is generated at 4150 v. and is distributed through 8 feeder circuits. A 33,000-v. switching structure, provided with remote control oil circuit breakers and metering equipment is located on the southeast corner of the property and from it 35,000-v. transmission lines extend north, east, south and west.

Gas and Oil Fired Boilers Are Used

Boiler equipment consists of three 414-hp. Stirling boilers, two of which are arranged in one battery with the third forming a one-half battery, but so arranged that the installation of another boiler will complete the battery. These boilers are equipped with Babcock & Wilcox superheaters for 150 deg. superheat, and the plant carries a steam pressure of 200 lb. All boilers are equipped with Duquesne burners of the combination oil and gas type installed under dutch oven extensions to the furnaces. Gas is supplied at 150 lb. pressure to a regulation station on the property where the pressure is reduced to 25 lb. and then to a regulator in the gas meter room where it is further reduced to an eight-ounce pressure. Duplicate meters of 100,000 cu. ft. capacity, arranged for testing, are located in this room.

An oil unloading rack along the plant spur track accommodates two cars at a time. Oil is pumped from cars by a Tennant-Lovegrove motor-driven triplex pump into a 160,000-gal. oil storage tank. Near the boiler room is situated an auxiliary oil tank with 1200-gal. capacity from which a duplicate oil heating and pumping set heats and circulates the oil through the oil burner heaters. The oil burners are of the steam atomized type.

Water, which is obtained from either the city's supply or by gravity from a nearby lake, is pumped into a 75,000-gal. house service, elevated tank and is softened in a Booth water softener and rapid pressure filter. From the clear water reservoir the water is handled by a Yeomans centrifugal make-up pump to a Hoppes open-feed water heater of 75,000 lb. capacity. There are duplicate feed water pumps which are Cameron four-stage centrifugal pumps driven by Terry steam turbines.

Recording flue gas thermometers, boiler feed water thermometers, and steam flow meters are provided for each boiler, as well as a recording CO_2 meter and a Venturi meter on the boiler feed water.

Ammonia Ice Machines Are Installed

In the engine room there are two York ammonia compressors of 75 and 40 T. capacity. To each of the machines is connected a York uniflow steam engine which operates condensing. The condensing equipment is a 1000-sq. ft. condenser, with motor-driven air and condensate pump and motor-driven circulating water and booster pumps. A natural draft cooling tower with spray nozzles in the upper section is provided. Thirty-two stands of the flooded type of ammonia condensers and eight stands of distilled water coolers are placed directly under the tower.

Two freezing tanks, containing 1600—300-lb. cans are provided with compressed air hoists and vertical motor-driven agitators. Water for ice making is taken from the condensate of the ice machine engines and the turbines of the electric plant and is boiled in a vacuum type reboiler. Three charcoal filters and two cooling tanks are provided. The day storage room has a capacity of 120 T. of ice, and directly over this room are located eight cold storage vaults for commercial use. The vaults and the day storage are cooled by brine coils, the brine being supplied from either tank by motor-driven centrifugal pumps. An elevator is provided for the commercial vaults. Adjoining the day storage room is the season storage. The capacity of this room is 2000 T. It is cooled by direct expansion, the coils being placed on three sides and the ceiling. The insulation in all of the cold storage rooms consists of 5-in. corkboard with a mastic finish.

Fuel Economy Secured by Organization

European Countries Study Economical Use of Fuel and Supervise Boiler Plants; Instrument Developed for Studying Vibration; Sulphurous Coal Ruins Monuments. By J. H. Blakey

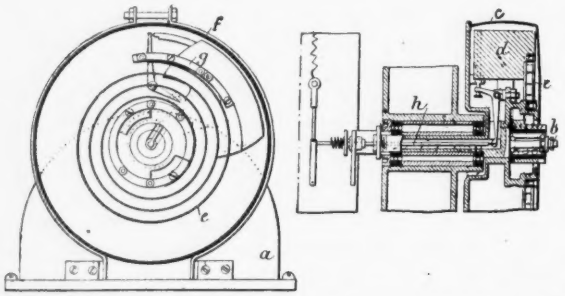
Seventh annual report of the French commission for the utilization of combustibles in industry appears in the Journal officiel; it is drawn up by M. Mahler and deals with the efforts being made in France, and to some extent in other European countries, toward a systematic organization for fuel economy in the industries.

M. Mahler states that the commission, appointed in 1914 as a war measure, has still to meet the scepticism of manufacturers and engineers, so he proceeds to give a number of instances in which valuable economies have been effected through its efforts. The report also makes the suggestions that all technical schools should have, as a part of the regular curriculum, a course in heating dealing with the best methods of use of all the different combustibles, together with a study of those appliances which have proved to be most economical; and that all factory superintendents encourage in every manner possible by means of lectures, conferences and boiler room demonstrations, the dissemination of the most recent knowledge in the technique of heating among the employes who are engaged in this part of the industry.

As an example of a private organization of this nature, that of the Societe des Forges et Acieries de la Marine et d'Homecourt is cited. This includes a local and a central service. The duties of the local service are to supply and keep in condition the measuring instruments; to make experimental studies with the furnaces in co-operation with those having charge of these furnaces; to collect a complete literature on the subject of industrial heating, and to turn in weekly reports on the consumption and production of each plant. The duties of the central service are to combine the efforts of the local services; to centralize the information and literature collected; to publish comparisons of the con-

sumption of the different plants, and to exercise a general supervision over the purchase and consumption of combustibles for the whole establishment.

Another private organization is that of M. Schneider at the Creusot plants. This includes a section of industrial heating and a boiler service. The duties of the industrial heating sections are as follows: The establishment of consumption programs for the different sections; control of the deliveries from the contractors; distribution of combustibles according to their nature to the appliances capable of making the best use of them; study of appliances most appropriate for new installations; the drawing up of specifications for new appliances or combustibles, and a comparative study of propositions received; after the construction of new furnaces, tests in the presence of a representative of the contractor; study of appliances already existing and of propositions for the modification or replacement by more modern or economical furnaces. Supervision of instruments of



SEISMOGRAPH PRINCIPLE IS EMPLOYED BY THIS DEVICE FOR LOCATING CAUSE OF VIBRATION IN HIGH SPEED MACHINERY

control or registration on furnaces in order to follow scientifically their functioning; collection of technical literature, French and foreign, relations with manufacturers or inventors of new appliances for heating, and visits to plants using new appliances or methods of heating.

Boiler service controls each day and for each group of boilers the amount of coal consumed, the quantity of water vaporized and the registration of pressures. In addition, combustion is controlled by means of indications furnished by a CO_2 recorder placed in each chimney, from which a sample is taken during each shift, and by registering draft gages on every boiler. The indications furnished by these serve as a means of awarding premiums to the firemen for the most economical operation of the boilers. Finally, each boiler undergoes an interior inspection every three months. Since this boiler service was put in operation the average consumption of fuel has decreased about 15 per cent.

When the French Government took possession of the mines of the Sarre Valley, its attention was quickly drawn to the enormous amount of coal being used at the collieries. An organization was appointed which began supervision of coal consumption in 1921. Thirty supervisors were put to work; their duties were to instruct the firemen, to equip all boilers with modern instruments, which were supplied by l'Office Central de Chauffe in Paris, and to do whatever could be done to remedy the situation generally. They found conditions very unsatisfactory; the first tests of chimney gases gave a maximum of 9 per cent of CO_2, the drafts were too strong and the temperature of the chimney gases too high. In one year they have increased the CO_2 to 11 per cent, the chimney gas temperature is reduced from 300 to 250 deg. C. and they have substituted an inferior coal for what was being used, in addition to a decrease of 1 per cent in the amount consumed.

Organizations existing outside of the plant are two in number: the Associations of Steam Boiler Owners and the Office Central de Chauffe. There are now 10 of these associations with 11,000 members controlling nearly 35,000 boilers. They maintain a service similar to those in the plants for the benefit of the members, and since electricity has come into use service in this line has been added. The Office Central de Chauffe was created in 1919, at a time when the combustible crisis was especially acute, by a group of coal-owners with a subvention from the government.

To reach the end in view the office has organized the following services: A school of industrial heating, having courses for engineers who already possess a regular technical training, and courses for overseers who intend to become boiler room superintendents or furnace managers. A documentary center for study and investigation, so as to keep abreast of advancing knowledge in all matters concerning industrial heating, in France and abroad. A laboratory for the special duty of combustibles and combustion. This laboratory makes tests or analyses of combustibles of all kinds, as well of combustion gases, feed water, etc. A service for the inspection of plants. Specialists are sent to the plants on the request of the management, and after a thorough investigation of all matters relating to heating they present a report, together with suggestion to the owners. As the work of the office has developed the visit service has been divided into sections; boiler inspection, metallurgy, ceramics and glass manufacturing. The office also makes a business of an economy propaganda, by publishing the results of its investigations, by public conferences and by exhibitions. During the three years in which it has been in operation the decrease in fuel consumption of the various plants served has run from 10 to 25 per cent.

Comment is also made in the report on the German organization, which is of such remarkable thoroughness and scope that it ought to be better known. In all the larger industrial enterprises special services have been created, and there is scarcely an important plant in which the calories are not carefully kept account of and controlled. But that which has been most effective is an organization outside of the plants, which includes a number of interrelated services. In Berlin a central office gathers information and puts it into permanent form, puts into communication all institutions interested in fuel economy, makes investigations and experiments, calls conferences, publishes a bulletin, etc.

Various industries, metallurgy, ceramics, glass works, Portland cement, have formed throughout the whole country, heating offices, specialized by industries and in connection with the central office. Boiler owners' associations are also in communication with each of these special offices and also with the central office in Berlin. For more than 2 yr. past, the German government has been contributing half a million marks per month, which, considering the purchasing power of the mark in Germany, is a considerable sum. At first, factory owners

were skeptical about the value of the service; but as results amounting even to 30 per cent saving have been shown, skepticism is disappearing and rapid progress throughout the whole country is being made.

Summing up the report, M. Mahler gives an idea of the saving possible in various industries. In a previous report, an average of 50 tests gave 65.7 per cent boiler efficiency; M. Brownlie in England has found an average of 60; the tests made by the Office Central de Chauffe averaged 62; whereas after the changes suggested by the office the efficiency has risen to 75 per cent and occasionally higher. In the utilization of the steam similar economies are possible.

Analysis of the Vibrations of High Speed Engines

One of the necessary conditions to the proper functioning of a turbine, or of any machine running at high speed, is the absence of vibrations; it is therefore necessary to be able to localize vibrations in order more easily to determine the cause. An apparatus for this purpose has been recently introduced in Germany, where it is used for the investigation of the vibrations in the bearings of high speed Diesel motors and large turbines. The principle of this appliance is the same as that of the seismograph; the vibrograph reveals the relative movement of the part in vibration in relation to a fixed mass, and registers these vibrations upon a chart which is moved by clockwork. Measurements can be made of vibrations which are hardly perceptible to the touch, as well as of oscillations of an amplitude of one centimeter and a frequency of 15,000 per min.

Having a weight of only about 13 lb., the vibrograph is bolted by its base upon the part of the machine to be studied. A weight d turns around a hollow axis b and is connected to this axis by the spiral spring e; a protecting casting c also turns around the axis, carrying with it the weight by means of the spring. The weight and the casting can be turned into any position and are held in position by the band f. The relative movement of the weight and of the casting caused by the vibrations, and which is tangential to the axis, is transformed by a system of levers into an axial movement transmitted by the central shaft h to the stylus bearing on the chart. When the central radius of the weight is in the vertical plane, the vibrograph indicates any horizontal vibrations; when it is in the horizontal plane the vertical vibrations are recorded, and so for all planes of vibration. An adjustable runner g enables the spiral spring to be kept at proper tension for any position of the weight.

Zeit. Vereines deut. Ing. gives an account of some experiments with the vibrograph. In one case a 10,000-kw. turbine running at 3000 r.p.m. was vibrating badly. The vibrations seemed to be due to some axial force which could not be explained until it was found that one of the bearings was not exactly above the neutral axis of its supporting column In another case it was found that the movement of the machine was driving a current of warm air over certain supports, the result being that the elongation of these supports produced a defect in the alinement, which in turn caused the excessive vibration.

Disintegration of Limestone by the Sulphurous Gases in Coal Smoke

An eminent French engineer, M. Florentin, has recently made a very careful study of the constitution of coal in order to see what can be done in France in the direction of fuel economy. In his reports he has drawn attention to the dissemination in the atmosphere of Paris, especially of enormous quantities of sulphurous gases, which attack limestone and are threatening to destroy completely many old monuments of this material. This engineer, in co-operation with the director of the Municipal Laboratory of the City of Paris, has made an investigation of this subject, and they have jointly produced the following communication, which was presented to the French Academy of Sciences at the meeting of Nov. 20, 1922:

"Eighteen months ago, in consequence of the deterioration of limestone monuments in the cemetery of Pere-Lachaise, we were charged by the municipal administration to seek the cause of these injuries. For this purpose the monuments known to be damaged were examined, and also other masonry work in which the damage was less evident. The result of this examination was to reveal partially decayed masonry all over the city of Paris. The chemical analysis which we have made upon limestone in a crumbling condition, and also upon specimens still in good condition, taken from different parts of the city, leaves no doubt in our minds that the damage is due to the sulphuration of the stone.

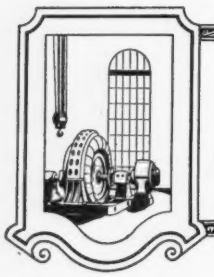
"In addition, we have observed that the starting point of the disintegration corresponds to the portions of the masonry covered with 'calcin'—which is a blackish varnish found on those stone projections which are protected from the action of the rain. It is probable that this calcin plays an important part in the crumbling process. (Here follows a chemical analysis of the calcin scraped from masonry in various parts of the city.) The conclusion drawn from these analyses is that it is the action of the sulphuric acid contained in the rain and snow, in consequence of the sulphurous gases in the atmosphere, the amount of which for Paris and its environs is reckoned at 240,000 T. annually, which causes the crumbling of the limestone."

Formula for the Heating Value of Coal

It is fairly well agreed that for any given mine, the constitution and average properties of the coal extracted remain uniform during a considerable period. Basing his argument on this proposition, M. Jacques Fohlen has established a closely approximate relation between the calorific power of a coal and its water and mineral content. The Revue Chimie et Industrie for August gives in detail the calculations which result in the following equation:

$$X = \frac{100 - H + C}{100}(6H + cC)Q$$

in which X is the industrial calorific power of the coal, in calories, H and C the percentage of water and mineral matter respectively, Q the calorific power of pure carbon, and 3×100 the heat energy required for the transformation of one gram of mineral matter. Four specimens of coal from the Sarre basin have been tested, and the following values for Q were found: 8225, 7975, 7600 and 7500 calories. For c the values were 9.25, 7.4, 9.75 and 4. A French calorie is 3.968 B.t.u.



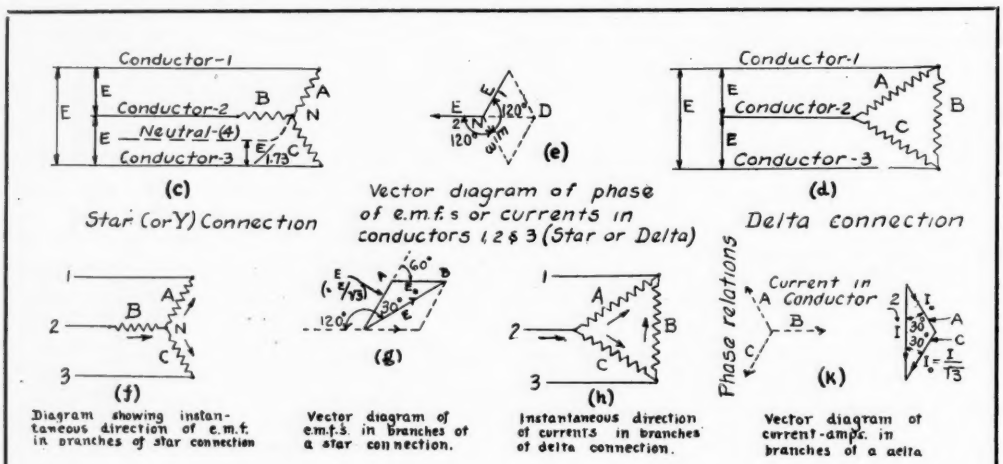
ELECTRICAL MACHINERY FOR LIGHT AND POWER

Alternating Current Transmission Lines

PART I. GENERAL CHARACTERISTICS AND CONSIDERATIONS REGARDING 3-PHASE CIRCUITS. BY E. K. McDOWELL*

ALTERNATING CURRENT transmission lines may be classified broadly under two main headings, i.e., long lines and short lines. The class of alternating current transmission lines treated in this series of articles is limited to what is commonly termed "short transmission lines" and generally understood to include circuits up to, say, about 30 mi. in length, and of voltages up to 30,000 or thereabouts. More specifically speaking, the class of circuits dealt with will be those in which the effects of capacitance may be neglected without material error. This includes in general two main groups:

(1) Non-inductive circuits, where the electrical characteristics are such that the effects of inductive



Properties of Star Connections—

If

E.M.F. between main conductors = E

Current (amp.) per conductor = I

Then

E.M.F. per branch, $E_o = E/\sqrt{3}$

(conductor to neutral)

or $E_o = E/1.73$

(See sk. "g")

Current (amp.) per branch = I

Power (watts) per branch $= \frac{IE}{\sqrt{3}}$

Total Power (watts) delivered to (or by) the three conductors $P = \sqrt{3}IE$

$= 3I\ (E \div \sqrt{3})$

Properties of Delta Connections—

If

E.M.F. between main conductors = E

Current (amp.) per conductor = I

Then

E.M.F. per branch = E

Current (amp.) per branch, $I_o = I/\sqrt{3}$

or $I_o = I/1.73$

(see sk. "k")

Power (watts) per branch $= \frac{IE}{\sqrt{3}}$

Total power (watts) delivered to (or by) the three conductors $P = \sqrt{3}IE$

$= 3E\ (I \div \sqrt{3})$

FIG. 1. DIAGRAMS AND PROPERTIES OF STAR AND DELTA CONNECTIONS

* Chief Engineer, Donora Steel Works, American Steel & Wire Co.

reactance can, for practical purposes, be ignored. Such circuits can be figured by approximate methods that are similar to those used for d.c. circuits discussed in a previous article.

(2) Inductive circuits, where the conditions are such that these inductive reactance effects have to be taken into account.

Both of these types of circuits will be treated in future articles.

At this point it would be appropriate to outline some of the fundamental characteristics of a.c. circuits in general, but it is believed that readers interested in this series of articles are fairly well conversant with these matters. Accordingly such subjects as the general nature of alternating current (as "sine waves," etc.), the "effective" or r.m.s. values of current and e.m.f., and some other elementary principles, all can be assumed to be understood.

The general idea of vector representation of a.c. e.m.f. or current-ampere values can also be passed by; remembering that such values (if simultaneous) can be plotted as vectors, having an angular relation corresponding to whatever phase differences may obtain in a given case. The power loss in any a.c. conductor might also be mentioned; and is given by the same general equation as for direct-current, that is, $P_1 = I^2R$; which can also be expressed in terms of cir. mils. cross-section of conductor, as was done in eq. 3 of the first of these articles. Some mention is also in order here concerning the general subject of

Single and Polyphase Circuits

Most of the elementary principles applying to single-phase circuits (some of which are mentioned above) also apply to polyphase circuits. Some additional considerations are, however, involved, which take account of the number of phases and of the e.m.f., current-ampere, and phase-angle relations mutually obtaining among the two or more single "currents" that make up any given polyphase circuit. The most important of these relations have to do with three-phase circuits and will be explained further under later headings in this article.

Two-phase systems represent a comparatively early development in power distribution and are usually encountered only in some of the older installations; although still in use by certain power companies on some of their low voltage service circuits for combined lighting and power. A two-phase four-wire circuit is equivalent, in some respects, to two single-phase circuits, in each of which the same effective and current-ampere values obtain, but with the two "currents" differing 90 deg. in phase. They can be calculated as two single-phase circuits, each delivering half the total power of the four-wire circuit.

Most power systems use three-phase circuits for the main transmission lines and feeders, together with single-phase branches therefrom for lighting service. Transmission problems, therefore, usually involve either single-phase or three-phase lines, with the latter class of circuits predominating, since nearly all single-phase lines usually encountered are low-voltage local service circuits. It is therefore appropriate to give special attention to the characteristics of three-phase systems, which will be the main subject-matter of the balance of this article.

A three-phase circuit consists of a separate "outgoing" wire for each of the three phases, with a phase difference of 120 deg. obtaining between the currents in each wire, and with (sometimes) a common return or neutral wire. When the loads of the three main wires (or phases) are equal, there is zero current and voltage in the neutral wire, which can therefore be omitted. In other words the return (or "incoming") wires for each phase are combined in one neutral wire, and the algebraic sum of the three e.m.f.'s (likewise the three current-amp. values) thus merged is at all times equal to zero. In some cases the neutral wire is retained, for special reasons that will be referred to later, giving a three-phase four-wire circuit, which arrangement is used extensively by public service companies for local distribution feeders. When the neutral wire is omitted there results the usual three-phase three-wire circuit, which, aside from the class of feeders just referred to, is the customary arrangement for most three-phase lines.

Certain fundamental and important properties of three-phase circuits can be most conveniently developed by first considering, as a starting-point, the principal types of connections used between electrical apparatus and three-phase lines. The remainder of the present article will accordingly review as briefly as possible the usual methods of connecting such equipment as generators, motors, and transformers to a.c. circuits, and certain general properties of three-phase transmission lines will be discovered, as it were, in that connection.

Star and Delta Connections

There are two main methods of connecting either armature coils or the phase windings of transformers or other apparatus to three-phase circuits, known respectively as the star (or Y) connection, and the delta connection.

Diagrams of star and delta connections are shown below in sketches (c) and (d) respectively. Other sketches, together with tabulated notes below, show the principal e.m.f. and current relations involved in these two classes of circuits. While these sketches and notes relative to the properties of star and delta connections will be found more or less self-explanatory, further explanations will be given in the following paragraphs.

It will be noted that the Y-connection, which is diagrammed in sketch c, consists of three phase-windings, each having one terminal connected to one of the three main conductors or phase wires, while the other terminals of the three windings (or branches) are connected together at the neutral point N.

In the delta connection, illustrated in sketch d, the three windings, which (as in all these sketches) may be the phase windings of any generating or receiving apparatus, are connected together so as to form the three sides of a triangle, and the three main phase-wires are connected to the three corners of the triangle.

Both types of connections are widely used; the delta connection alone being employed (exclusively) in connection with many industrial power systems, and is used in some parts of practically every power and transmission system. The Y-connection is frequently encountered on certain portions of public service power systems. On such systems combinations of these two types of connections are also in common use; e.g., a three-phase circuit or transmission line may be supplied

from a Y-connected generator or from the three Y-connected primary (or secondary) windings of (say) three single-phase transformers. Then there may be one or more transformer groups, delta-connected to the receiving end of the circuit.

Another combination frequently employed is the so-called star-delta transformer connection; wherein one three-phase circuit is Y-connected to the primary windings of three single-phase (or of one three-phase) transformers while another circuit is delta-connected to the secondary or low-voltage windings of the same transformer group.

In Fig. 1, sketch e illustrates vectorially the phase relations existing between either the electro motive forces or the current in the three main conductors of any three-phase circuit, whether star or delta connected.

A relation can also be established between the current (amps.) I_o in each branch of a delta connection and the current I in each main conductor, or phase-wire. This relation will be found the same (numerically) as the e.m.f. relation for a "Y". Thus, $I_o = I/\sqrt{3}$ or $I_o = I \div 1.73$ ..... (5)

In general, the ratios of branch and line current and e.m.f. values in delta connected circuits are just the reverse of these relations for Y-connected circuits, as indicated in the tabulated notes under Fig. 1.

Power in "Y" or Delta Connected Circuits

In a non-conducting (unity power factor) single-phase circuit, the power is expressed by the equation P = EI, the same as in d.c. circuits. Similarly, if I_o be the current-amperes flowing in one branch of the

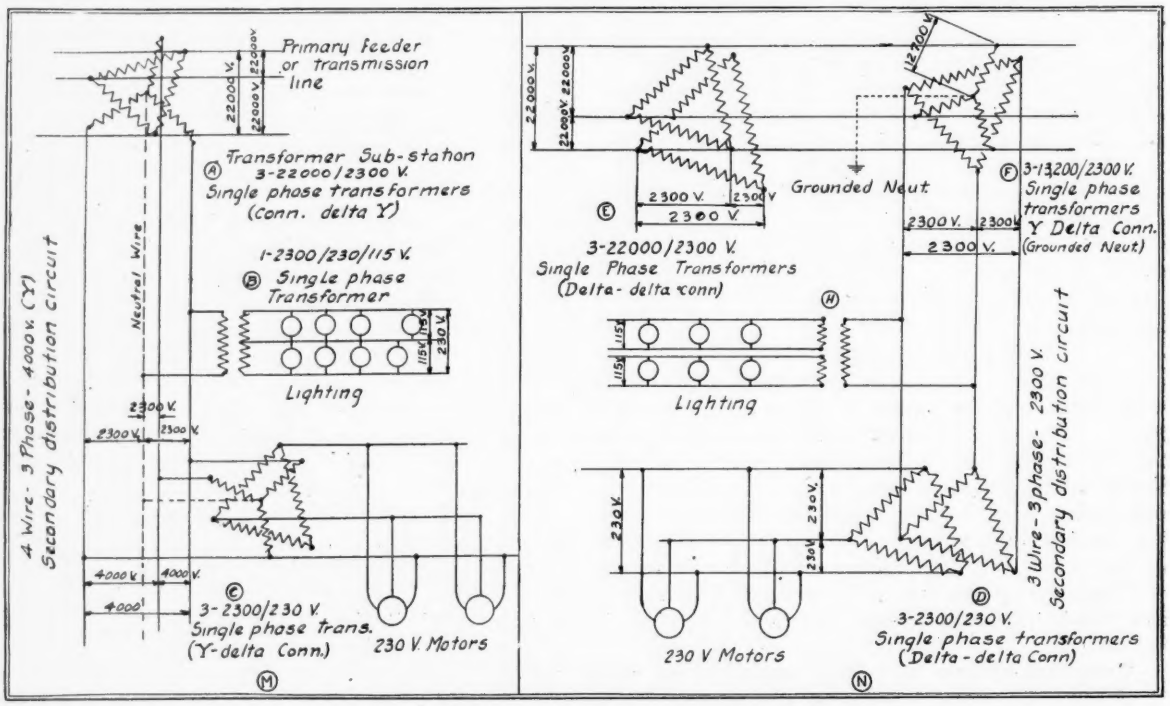


FIG. 2. TYPICAL 3 AND 4-WIRE DISTRIBUTION CIRCUITS

Note that ND, resultant of e.m.f.'s E in conductors 1 and 3, equals E but is opposite in phase to e.m.f. E in conductor 2.

Sketch g is a vector diagram from which is deduced the relation of e.m.f. in any branch of the star to the e.m.f. between any pair of conductors. NA and AB are each equal to E_o, the e.m.f. between one wire and neutral; and represent vectorially (and in correct phase relations) the e.m.f.'s in branches B and A of the "Y" shown in sketches c and f. The resultant of NA and AB is NB, or E, which is the e.m.f. between conductors 1 and 2.

Since both NA and AB equal E_o, and the angle ANE (also ABN) equals 30 deg., then $E = 2 E_o \cos 30$ deg.; but cos 30 deg. $= \sqrt{3/2}$, whence $E_o = \frac{E}{\sqrt{3}}$ or

or $E_o = \frac{E}{1.73}$ ..... (4)

Y of sketch c, and E_o be the e.m.f. in that branch, the power developed in that one branch will be $P_o = I_o E_o$ and the total power developed in all three branches will be $P = 3 I_o E_o$. But by equation (4) $E = E_o \div \sqrt{3}$; also $I_o = I$, the current amps. per main conductor. Therefore $P = 3 IE \div \sqrt{3}$, or

$P = \sqrt{3}$ IE or P = 1.73 IE ..... (6)

This is the general equation for the power in any three-phase alternating current non-inductive circuit, whether Y or delta-connected. This equation (6) is important, and the basis thereof should be well understood as being one of the fundamentals that are essential for the intelligent analysis and calculation of the performance of three-phase circuits.

General Aspects of Star and Delta Connections

On many three-phase transmission and distribution systems it will be found that delta-connections are employed throughout for all transformer connections. This

particularly applies to most steel plants having their own power-stations; accordingly readers of this matter who are affiliated with that industry will possibly encounter Y-connections very infrequently. A similar situation may obtain, to a certain extent, in connection with other industrial power systems. This is largely due to certain disadvantages associated with the usual practice of grounding the neutral point of a Y-connection and having to do with the possibility of frequent delays due to accidental grounds on Y-connected grounded-neutral systems. These particular difficulties do not obtain where the transformers are all delta-connected; in which case there is no grounded neutral.

Y-connections, however, particularly Y-connected transformers, are extensively employed in public service systems, extensive use being made of transformer banks connected star-delta. Y-connection of both primary and secondary windings, of the same transformer bank, is seldom used on account of the presence of certain irregular currents (so-called "harmonic currents") which, under these conditions, are liable to set up excessive voltage stresses in the windings.

When transformer windings are Y-connected (as in cases where the Y-delta connection is used) the object is, usually, to establish a neutral point; either for connecting the neutral wire of a three-phase four-wire circuit thereto, or in order to connect this neutral point permanently to ground. In the latter instance the circuit leading from this Y-connected side of the transformer is said to have a grounded neutral, which offers certain important voltage surges and disturbances. Another advantage of the Y-connection is that each transformer is subject to only 58 per cent of the line voltage (that is, E ÷ 1.73, where E is the line voltage between phases). In general this means a lower ratio of transformation, less number of turns in the winding and lighter insulation, which usually results in a less expensive transformer.

A certain advantage obtains from the use of delta connections on both sides of a bank of three single-phase transformers, due to the possibility of utilizing the so-called open delta (or "V") connection in the event of one transformer being crippled. This practically amounts to disconnecting one transformer from the delta, leaving the connections of the other two unchanged (like removing winding B from sketch h in Fig. 1). Under this condition the two remaining transformers will continue to supply the circuit, but at a total kv.a. capacity for the bank of but 58 per cent of the original combined capacity of the three units.

Without regard to extent of use, it is important that the characteristics of Y-connections be well understood, partly because the general nature of three-phase current can be best explained by the illustrative use of such connections; also because certain matters such as grounded neutral, Y-delta transformer connections, etc., which involve this type of connections, are becoming of increasing prevalence and importance. Furthermore, the properties of this connection are the basis of the so-called "Equivalent Y Method" which is generally used in calculating the performance of all three-phase circuits, whether Y or delta connection. This method will be explained in a later article.

Three-Phase, Four-Wire Circuits

Three-phase four-wire circuits previously referred to are Y-connected at the sending end and are provided with a neutral wire, which is carried throughout the circuit along with the three main phase-wires, and is connected to the neutral point of the three transformer windings which supply current to the circuit.

Circuits of this character are usually supplied from a bank of lowering transformers that are delta-connected on the high-voltage side to a main transmission line; while the low-voltage side is Y-connected to the four-wire circuit. This situation is illustrated in sketch m, as shown in Fig. 2, showing a four-wire secondary circuit supplied from a 22-kv. primary feeder. Three-phase motor service circuits are connected to the four-wire line either by banks of three single-phase transformers, or by three-phase units; in either case the high voltage side is Y-connected to the four-wire line and the low voltage side is delta connected to the three-phase, three-wire motor circuit, as indicated at C on sketch m.

Single-phase lighting circuits can be supplied from single 2300/230/115-v. transformers, connected between any one phase-wire and neutral wire of the four-wire circuit. The low-voltage windings of such transformers are commonly arranged in two equal sections with middle taps provided; thus one unit can supply a three-wire single-phase 115-v. lighting circuit (as at B on sketch m), or two two-wire circuits (as at H on sketch n), or a 230-v. circuit can be supplied as further indicated at B on sketch m.

For comparison, sketch n in Fig. 2 illustrates a typical three-wire, 2300-v, three-phase secondary distribution circuit, having similar service connections to the four-wire circuit of sketch m and shown as connected to the same 22-kv. three-phase primary feeder circuit. Note that this 2300-v., three-wire circuit can be connected to the high-tension (22-kv.) line either by a Y-delta-connected transformer bank, as shown at F on the sketch, or by a delta-delta-connected bank, as indicated at E. If the former arrangement be used each high-voltage (Y-connected) winding is subject to only 58 per cent (1/1.73) of the line voltage between phases, or 12,700 v.; accordingly a 13,200-v. three-phase transformer, or three single-phase units, would be used, this being the nearest standard transformer voltage class. The neutral point of the Y-connection should be grounded, as indicated on the sketch; if the delta-connected arrangement (shown at E, Fig. 1) is employed, each high-tension winding will be subject to full line voltage, and transformers of the 22,000/2300-v. class will have to be used. The service transformers, supplying the motor circuit (shown at D, Fig. 1) will be delta-delta connected in this case; whereas they had to be Y-connected to the four-wire circuit of sketch m, Fig. 2 (as at C) in order to utilize standard 2300-v. transformers.

Advantages of Three-Phase, Four-Wire Circuits

As compared to the three-wire arrangement, having 2300-v. between phases, the main advantage of the four-wire, 4000-v. circuit is that, due to the higher transmission voltage, smaller conductors can be used than for

a three-wire, 2300-v. line transmitting the same kw. of power. On an extensive secondary distribution system a considerable economy in copper is thus made possible; since the line current is less than for the 2300-v. system, consequently considerably smaller conductors will transmit the same power with the same line losses, and the total conductor cross-section is less for the four-wire circuit, the fourth (neutral) wire being included. In fact, it can be shown that the latter system requires only 67 to 50 per cent of the weight of copper in conductors that would be required for an equivalent three-wire circuit, assuming the neutral wire of the four-wire circuit to be the same size as the other three wires, which is the usual practice.

A further advantage of the four-wire circuit is associated with the above conditions; this is that a 2300-v. three-wire overhead circuit can readily be changed to a four-wire, 4000-v. circuit, by adding a neutral wire and generally changing the transformer connections from delta to Y; thus the original power transmitted can usually be more than doubled. When an existing 2300-v. distribution system becomes overloaded, the foregoing procedure furnishes an economical and convenient means of securing the necessary additional transmission capacity without making any very extensive changes or additions; provided, of course, that conditions in general are such that a four-wire circuit is appropriate.

Three-phase four-wire circuits are used quite extensively (but not always) as local overhead distributing circuits for public-service systems. Three-phase four-wire 4000-v. underground cable circuits are also employed by several metropolitan power companies for the same general purposes; four-conductor lead-covered cables being used therefor. This is done extensively in Chicago, and is to be the ultimate arrangement in Pittsburgh for all distribution feeders in the business section of the city. The neutral wire is generally grounded at the sub-station (or sending) end of each feeder.

NOTE. It is desired to call attention to an unintentional omission in the first of these articles which appeared in the Feb. 15 issue in that the current carrying capacity of bare copper conductors, Table I, should have been credited to Wm. Nesbit, being reproduced from his book, "Electrical Characteristics of Transmission Circuits," and were used in these articles by permission of the "Electric Journal" publishers of that work.

Another point in regard to this table to which attention is directed, is that the bracket enclosing the first three groups of values in the 3rd main column should have been extended to enclose the entire column.

The Measurement of Power in Polyphase Circuits

PAPER DELIVERED BEFORE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS PROPOSES CHANGE IN MAKING RATES. BY CHARLES FORTESQUE

IT IS THE object of this paper to point out that the existing methods of measuring power when applied to unbalanced three-phase systems are not equitable for symmetrical polyphase machinery. On the other hand, unsymmetrical loads on polyphase systems are not sufficiently penalized for the trouble which they create in the system.

In the original paper, it is first of all shown that a symmetrically wound generator cannot deliver power except through the balance components of currents. The unbalanced currents are capable of resolutions into two balanced systems of currents, one of which is of the same phase sequence as the generator electromotive force, and the other component is of reversed or negative phase sequence. The generator cannot deliver power through the medium of this latter component of the currents, because the instantaneous product of the generated voltage and these currents in the three phases is always zero. The volt-ampere product per phase, however, is of great significance, because it is a measure of the effect of current unbalance on the system.

The generator, therefore, delivers power only through the negative power that appears in the system through the negative phase-sequence currents. Any power that appears in the system through the negative phase-sequence currents is positive phase-sequence power which has been degraded through unbalanced loads and fed back to the system in the form of negative phase-sequence power. This power is always additional loss in all rotating machines on the system, and with the present method of charging, the consumer having symmetrical machines is charged with this additional power, which serves him no useful purpose, but reduces the output of his machine and decreases his load power factor.

SINGLE PHASE MOTORS

CONSIDERED FROM the point of view of symmetrical co-ordinates, single-phase motors are only a special case of three-phase motor unbalanced operation. The positive phase-sequence current and the negative phase-sequence currents are equal in magnitude; the unbalancing effect of such a motor is, therefore, quite definite and is equal to its positive phase-sequence kv.a.

It would appear reasonable to charge a consumer, using single-phase motor, on the basis of this unbalanced kv.a. whether other consumers using similar machines, when operating simultaneous with his, are connected, jointly to produce a balance or not. The cost of single phase service on polyphase systems should be based on the cost of unbalance, compiled from the previous year.

This method of charging could be extended to all single-phase power loads, and would be equitable except in the case of consumers having mixed loads, who should be encouraged to balance up the single-phase portion of their loads as far as practicable. It should be remembered, however, that single-phase loads even when perfectly balanced are inferior to balanced polyphase rotating loads, because the latter have high inherent balancing characteristics which the single-phase balanced loads do not have. That is to say, the admittance to negative phase-sequence current for a balanced single-phase load is the same as its admittance to positive phase-sequence current, whereas in the case of a polyphase synchronous or induction motor or rotating converter carrying the

same load, admittance to negative phase-sequence currents may be many times that to positive phase-sequence currents.

Single-Phase Lighting

The same comments apply to this type of load as to single-phase motors, except that the power factor being near unity, the lighting load becomes less objectionable from this standpoint. When it is possible to balance the loads on all phases, it should be done by the consumer as closely as practicable, and he should be charged on the basis of the polyphase power consumed and the unbalance he creates. At the present stage, it will be sufficient to charge him for his unbalanced kv.a. without considering whether he is helping or hindering the balance. This charge may be considered the penalty attached to single-phase service, which is reduced in proportion to the care with which the consumer arranges his circuits. This method of charging holds equally well for all single-phase loads where they can be arranged to give good approximate balance.

Three-Phase Furnaces

The three-phase furnaces may be balanced by introducing a properly designed control. With proper control, it should be balanced both as to current and e.m.f. between neutral and terminals. Under these conditions of balance such harmonics of current as occur will be a minimum. A practical method of obtaining balance is with the use of a series phase balancer which will be small as compared with the output of the machine. This should be combined with a voltage regulator to control the depth of the electrodes; in this way perfect balance as to the current as well as voltage may be obtained. Furnace loads when balanced have no inherent balancing capacity whatever, and therefore all unbalanced kv.a. should be charged for. In addition, if the wave form of current is very much distorted, some account should be taken of this distortion when the operating conditions warrant it.

Equitable System of Rates Based on Sequence Measurements

To avoid this obviously unequitable condition, it is proposed that the positive phase-sequence power output only be measured. The positive phase-sequence power delivered to a load may be measured by a single element wattmeter with the proper form of network constraint which can be incorporated in the meter. This positive sequence power, as has been pointed out, is the only power that the generator is capable of delivering. The total power delivered measured at the terminals of a symmetrical generator which carries an unbalanced load, is always less than the positive phase-sequence power. The difference is absorbed by the generator in the form of losses. In the case of a load causing unbalance, the positive phase-sequence power input will always include the negative phase-sequence power delivered to the system by the load as a result of the unbalance. Balanced polyphase loads, such as motors and balanced polyphase networks in general, do not contribute to the unbalance, but assist in maintaining balance. They absorb negative phase-sequence power, but do not transform positive phase-sequence power into negative phase-sequence power. Their operation as motors has nothing to do with their phase-balancing characteristics and is dependent solely on the positive phase-sequence power taken. There is always less than the positive phase-sequence power. so small that it may be neglected in the motor power, absorbed by reason of the balancing effect which is dissipated in the secondary windings as $I^2 R$ loss. The motor is performing an important service as a phase balancer for which, with the present method of charging, it is penalized. If only the positive phase-sequence power delivered is measured and charged for, this penalty will be removed and placed, where it should be placed, on the unbalanced loads on the system. The consumer who uses polyphase motors should get a polyphase rate somewhat lower than that for other kinds of polyphase load depending upon the estimated cost of unbalancing.

In the case of the consumer having a mixed load, if his single-phase load is of sufficient importance, it may be metered separately. If it is small as compared with the polyphase motor load, it may be connected so as to produce a minimum unbalance and the charge should be based on the positive phase-sequence meter reading and a rate obtained by taking the weighted average of the polyphase rate for single-phase balanced networks and that for polyphase motors, based on the respective value of the wired single-phase and polyphase loads.

In the case of single-phase loads connected so as to minimize unbalance, the power charges should be made on the basis of the positive phase-sequence power. A charge should also be made for negative phase-sequence kv.a. obtained by means of a recording negative phase-sequence current device, in the same manner as reactive power is charged for, the cost of unbalance being computed from previous results.

To sum up: Positive phase-sequence power is the only commodity manufactured by the power plant; phase balance is a service to which all consumers using polyphase motors contribute and with which users of single-phase devices interfere. Users of balanced polyphase power other than motors should pay for this service in the regular polyphase rates. Users of single-phase devices should pay over and above the regular polyphase rate depending upon the amount of unbalanced current they create. Users of polyphase motors should obtain a lower polyphase rate, based on the average amount of service they contribute to the maintaining of balance.

The meters required for assigning the proper charges are as simple or simpler than those used at the present time for polyphase power measurements and the results should prove more satisfactory and equitable all round and are based on correct theoretical grounds.

Characteristics Required to Maintain Balanced Polyphase Service

It is essential to the maintenance of good balanced polyphase service that all banks of transformers should be symmetrically grouped that all transformers in one bank shall have the same performance and characteristics. It was not unusual in the past to find rotary converters connected to polyphase systems through a bank of open delta-connected transformers; such practices should not be tolerated except for short intervals while starting or under emergency conditions.

All feeders used to supply mixed loads should be loaded as symmetrically as possible. They should have

as low impedance as possible for two reasons: (1) so that the effect of starting and stopping motors will not affect the lighting service unreasonably; (2) in order to reduce the voltage unbalance caused by any given value of unbalanced load they may incur.

Where a polyphase circuit is called upon to supply a large single-phase load, special provision should be made for the service such as heavier feeders and in many cases balancers or phase converters should be installed.

In selling power to a consumer of this kind the cost of the converter station will naturally enter into the rates charged for power, otherwise the rates used will be the regular polyphase rates for power.

Dissymmetry in transmissions, feeders, etc., should be avoided with careful transpositions, dissymmetry in conductor arrangements may be compensated. In long transmission systems when synchronous condensers for regulating purposes are distributed over the line, they will also serve the purpose of phase balancers.

The fact that normal overloads have the characteristics of remaining balanced offers great possibilities in the way of protection on feeders, selective operation and so forth. For if a loaded system is normally balanced, we may employ a positive phase-sequence relay for load control having the proper time element, and for short-circuit control, we may use the negative phase-sequence principle, and since negative phase-sequence current flows only under short circuit, complete selective operation may be obtained.

There are many more applications of this principle the apparatus protection and control, too many to enumerate, that will suggest themselves to anyone who takes the trouble to study this subject.

Economizer Cleaned by Washing While Operating

NEW TYPE OF STEEL TUBE ECONOMIZER HAS WATER SPRAY FOR CLEANING. STEEL TUBES ARE ENCLOSED BY CAST-IRON GILLED RINGS

ONE rather unusual feature of the Foster economizer, which has recently been placed on the market, is in the method of cleaning with a water spray. As will be noted from the accompanying illustrations, the economizer tubes are made up from steel tubes which are entirely enclosed by a series of cast-iron gilled rings. In order to clean out the crevices between these rings, the washing method has been adopted rather than the use of blower elements.

Each economizer is equipped with permanent spray pipes placed above the top row of elements and perpendicular to them. Each group of these spray pipes is controlled by a quick-opening gate valve which connects to the washing-water header. This arrangement permits the easy admission of water into any spray pipe desired. Cross slots are cut in each spray pipe so that water passing through these falls directly on each of the elements in the top row.

In practice the economizer is washed down while in service, at intervals of once or twice in 24 hr. and the process takes but a few moments. The water is admitted into only one group of spray pipes at a time and flows down over one row of tubes after another, the corrugations always keeping the water in the vertical plane from which it started. This insures a compact body of water covering even the lowest tubes in the bank and also prevents the water from spreading longitudinally along the tubes and unduly congesting the draft. All the heating surface is, therefore, kept free from soot and dirt and the material removed is carried into the cast-iron pans forming the bottom of the economizer casing and thence to the drain pipe.

While it is necessary to maintain sufficient pressure in the washing-water header to insure an ample supply during the cleaning period, the pressure is not depended on to remove the residue of combustion. The volume of water carried downward by gravity floods the soot from the elements instead of the velocity of the water striking the dirt from the surface. Ordinarily the pressure in the water main is sufficient for the washing supply and this is used at the main temperature.

One decided advantage of using water to wash the heating surface of the economizer is the complete prevention of pitting by the sulphuric content in the furnace gases. While dilute sulphuric acid is known to be an active corrosive agent, the amount of water admitted during the washing process is so great, in comparison to the quantity of acid formed, that it completely flushes the acid away. When the washing process is completed, the temperature of the gases in all parts of the economizer chamber is sufficiently high to evaporate the residual moisture immediately and the surfaces are, therefore, left not only clean and dry but free from the dangerous effects of acids.

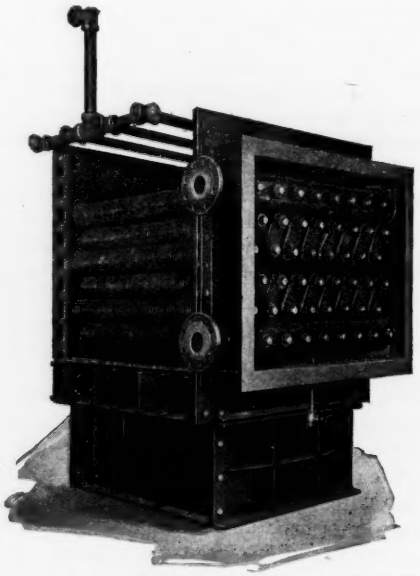


FIG. 1. ECONOMIZER WITH SIDE PLATES AND END DOORS REMOVED WITHOUT INSULATION IN PLACE

In Fig. 2 is shown the performance of the washing water while one of the spray pipes is in operation. Although a portion of the heating surface is being thor-

oughly washed, the water offers no interference with the passage of the gases through the remainder of the economizer chamber.

It will be noted that the heating surface is entirely covered with cast-iron and the tube sheets that support the elements as well as the interior lining of the side walls are all of this material. The washing water, therefore, comes in contact only with cast-iron surfaces. The inner casing is built watertight so that all of the washing water is conducted down the drain piping.

As may be seen from Fig. 3, the pressure element consists of a 2-in. steel tube on the outside of which is tightly fitted a series of cast-iron gilled rings. The ends of each of these ring castings are faced with male and female joints to insure the complete protection of the steel tube and subject only the cast-iron covering to the

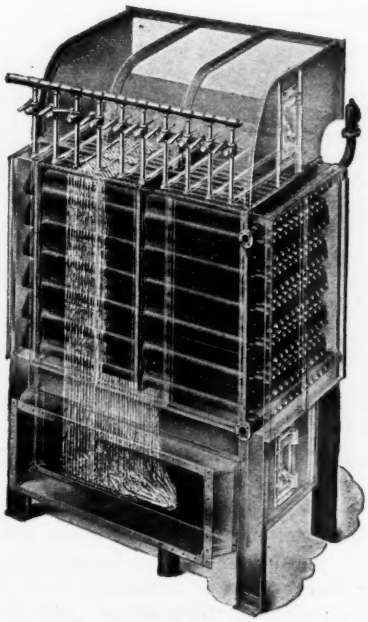


FIG. 2. PHANTOM VIEW OF ECONOMIZER SHOWING THE ACTION OF THE WASHING WATER

furnace gases. It should be noted that in service the steel tube, which is recognized as the strongest practical material for this work, resists the water pressure, and the cast iron, also recognized as the best material for its function, resists the corrosive action of the furnace gases. This extended surface, having a decidedly greater outside area per unit of length than any bare tube, requires a minimum space and permits of a construction much less bulky than that which could be obtained by any smooth surface.

Straight tubes, easily cleaned internally with a turbine cleaner, are expanded into cast-steel return headers. These headers are equipped with machined steel hand-hole plates which consist of a tapered plug, copper gasket, yoke and nut as illustrated. These plugs seat with and are held in position by the pressure and are easily removed for inspection or repair. The inlet and outlet connections consist of forged steel manifolds into which a series of elements is expanded. This arrangement allows the water to circulate through the tubes of each of the rows in series and the individual return headers connecting each of these tubes permit the free expansion of each element.

The elements are always placed horizontally and the number of tubes in each horizontal row is governed by the quantity of water to be heated. The number of rows in the vertical plane is established by the temperature desired in the feed water.

Cast-iron tube sheets which are perforated to receive the elements, act as the end supports for the economizer tubes. The holes in the end plate next to the inlet and outlet manifolds loosely fit the bare tube of the element and bosses are machined on the inside face of these to fit the male end of the gilled ring. The holes in the

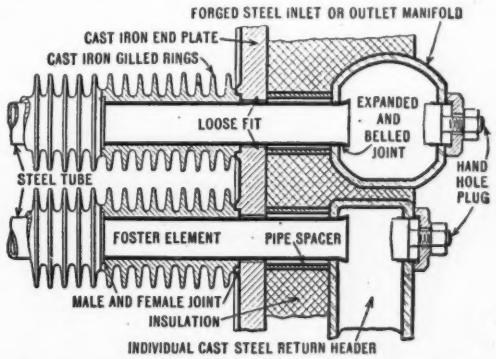


FIG. 3. TUBES ARE EXPANDED INTO THE TUBE SHEET AND MANIFOLD

opposite end plates loosely fit the outside of the gilled rings. These details are shown in Fig. 3. Each element is thus supported independently of the others and may be withdrawn without damage or removal of any other element.

It will be seen that all of the expanded joints are outside of the gas passage and that the cast-iron rings entirely protect the steel tubes. It is, therefore, possible to drain the water from the economizer, remove the hand-hole plugs and re-roll any joint without shutting down the boiler unit.

Construction of the economizer is in accordance with the practice for high-pressure boiler construction and the economizer is, therefore, able to carry the full boiler pressure. This feature permits of the simplest pumping arrangement possible and gives it very decided advantages over a low-pressure economizer which requires a pump between it and the boiler or over any combination of high and low-pressure economizers, which requires a separate pump or a separate set of stages on the same pump between the low and high-pressure units. This type of economizer is built by the Power Specialty Co. of New York City.

IT HAS BEEN SAID that the overall is the barometer of business, and probably there is more truth than poetry in this statement. A low barometer in overalls means disaster for business, whereas the high barometer in overalls means good business. The Bayly-Underhill Manufacturing Co., of Denver, Colo., employing 300 persons, running 15 per cent ahead of the output of 1921, and in 1921 something over one million garments were turned out. Such news should put to rout old man Gloom.

Checking Up on the Absorption System

Operating Pointers Which Aid in the Efficient Use of the Exhaust Steam Type of Refrigerating Machine. By Heywood Cochran*

WHILE THE absorption refrigeration system is comparatively simple and there are few moving parts to get out of order, there are nevertheless certain factors in the operation of this equipment which must be given attention to secure the best operating results. For instance, the causes of lack of capacity such as insufficient water supply, insufficient steam pressure, insufficient flow of brine, insufficient ammonia charge, air or non-condensible gases in machine, dirty condenser, absorber and rectifier coils, cooler in need of purging, are some of the points which must be considered in placing the equipment in good working condition.

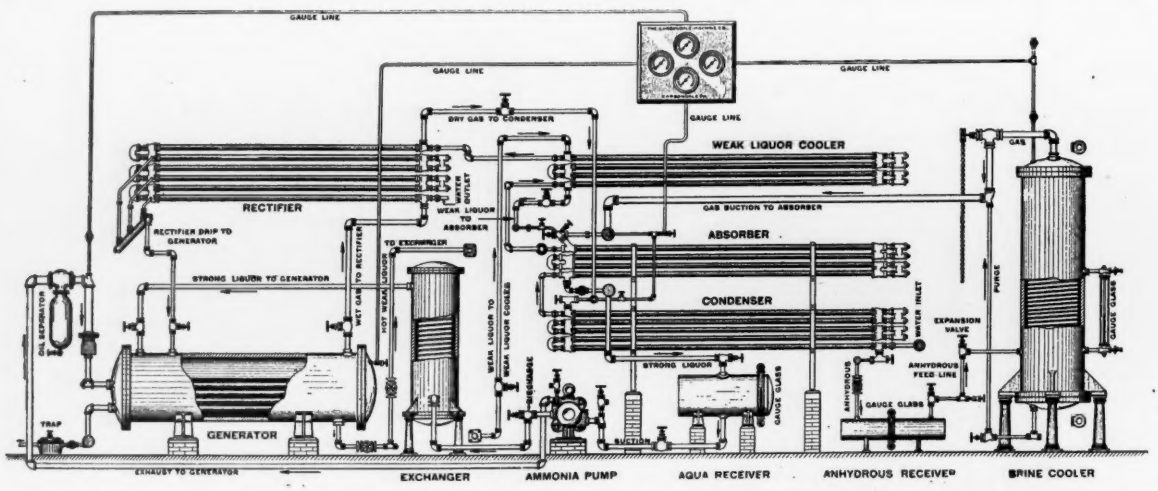


FIG. 1. ALTHOUGH THIS LAYOUT IS FOR THE DOUBLE-PIPE TYPE OF MACHINE THE GENERAL METHOD OF OPERATION IS THE SAME FOR OTHER TYPES OF MACHINES

One important feature of operating economy is in the amount and temperature of the water used for cooling. The quantity should be as regular as possible and the coldest water available should be used. The following quantities are recommended although in some cases it may be possible to get along with less, while, on the other hand, a distinct betterment of economy may sometimes be effected by using more.

With a water temperature of 50 deg. F., use 2 gal. per min. per ton of refrigeration; 60 deg., 2½ gal.; 70 deg., 3¼ gal.; 80 deg., 4¼ gal.; 90 deg., 6 gal.

It is well to consult the specifications or the individual manufacturer to ascertain the correct amount of water to use in each individual case. The outlet water from the absorber should never exceed 95 to 100 deg. F. Sufficient water should be used with the rectifier to keep the outflowing gas at a temperature not over 20 to 30 deg. F. warmer than the ammonia condensing temperature. In the accompanying table is shown the temperatures between which this rectifier gas outlet should be held. It will be found that when the rectifier is operating normally, is clean and has a good water supply, the shortest drip pipe will be very hot, the intermediate pipe or pipes successively cooler, and the longest pipe fairly cool to the hand. In judging temperatures by the hand, it should be borne in mind that a temperature of 120 deg. F. is about as hot as can be borne by the hand, while a temperature of 100 deg. F. is about blood heat.

In general, the steam pressure varies between 3 lb. with zero brine and 60 deg. F. water to 50 lb. or more with 20 deg. F. brine and 80 deg. F. water, depending, of course, on the design of the machine. For specific data, the specifications under which the machine was sold should be consulted. It may be said, however, that the steam pressure must be increased if the brine temperature is lowered or the cooling water temperature raised. For example, with 150 lb. generator gage pressure, 50 lb. steam pressure on the generator is the maximum. If the machine is properly charged to do full capacity, a higher steam pressure will tend to dissociate the ammonia gas.

To make sure that the generator steam coils are clear of air and condensation, an air cock is usually provided on the bottom header for the purpose of relieving air from the coils and also indicating whether any condensation backs up in the coils. At times steam traps do not work properly and it is always well to keep this air cock open slightly to indicate any accumulation of condensation which may occur. When the machine is shut down,

IF GENERATOR PRESSURES ARE HIGHER THAN THOSE GIVEN HERE, THE SOURCE OF THE TROUBLE SHOULD BE LOOKED FOR

Water temp. Deg. F.	Generator gage press. lb. per sq. in.	Temp. gas leaving rectifier, deg. F.
50	105	86 to 96
60	125	95 to 105
70	145	102 to 112
80	166	109 to 119
90	192	118 to 128

*Sales engineer, Carbondale Machine Co.

except for long periods, a little steam should always be allowed to enter the generator coil so as to keep the shell warm and prevent leakage of ammonia, due to the contraction of the coil tails and packing where they pass through the generator heads.

If the generator gage shows that the ammonia pressure is higher than that shown in the table, it indicates one of the following three conditions: insufficient water supply, air in the high pressure side of the machine or dirty coils. With a normal charge, the cooler gage pressure should correspond to an ammonia temperature from 5 to 10 deg. F. lower than the temperature of the outgoing brine.

It is usually recommended that 73 to 75 per cent calcium chloride, free of salt and magnesia, be used for making brine for an absorption system. This should usually be carried at a specific gravity of from 1.225 to 1.250 for cold storage plants and near 1.175 for ice tanks. Ordinary salt brine is not suitable for use with a brine cooler, as it is apt to freeze and burst the coils or tubes. It can, however, be used with an ice tank with success.

With a brine cooler and circulating system, the brine pump should be of sufficient capacity to circulate at least 2½ to 5 gal. of brine per min. per ton of refrigerating capacity of the machine. The brine must be kept in motion and circulated through the cooler at this rate while the machine is in operation. If the calcium brine is weak, there is a liability of the cooler coils freezing, which would be indicated by a sudden stoppage of the brine pump if of the displacement type. In such an event, immediately close the gas valve between the cooler and the absorber and open up the expansion valve wide for at least 5 min. This should heat the brine sufficiently to thaw it and to permit the pump to start. It is well to shut the steam off the generator until the cooler is thawed out. This procedure is one of the advantages of the absorption machine.

Aqua ammonia is contained in the generator, exchanger and absorber and anhydrous ammonia is contained in the condenser and cooler. With the machine in regular operation, and a normal charge, the generator will have from 1 to 2 in. of liquor covering the coils while the absorber will contain ammonia as follows, depending on the type:

Tubular absorbers have about 1 in. of aqua ammonia over the top row of tubes, while atmospheric and double-pipe absorbers have at least 12 in. of aqua ammonia in the aqua receiver above the pump suction connection. Shell absorbers run practically empty and should show nearly level with the lower flange joint of the shell and head. The shell condenser should show 4 to 6 in. of anhydrous ammonia in the gage glass while the receivers of atmospheric or double-pipe condensers will show a similar amount in the gage glass above the outlet to the expansion valve, or at least sufficient to cover the outlet so that the gas cannot blow through. The brine cooler should have enough anhydrous ammonia in it to frost over both gage cocks and to show a flash of soapy liquid in the glass when the gage cocks are opened. The gas line should be slightly frosted back to the absorber although it should never frost sufficiently to show frost on the purge line, as this would indicate that liquid ammonia was being carried over out of the cooler.

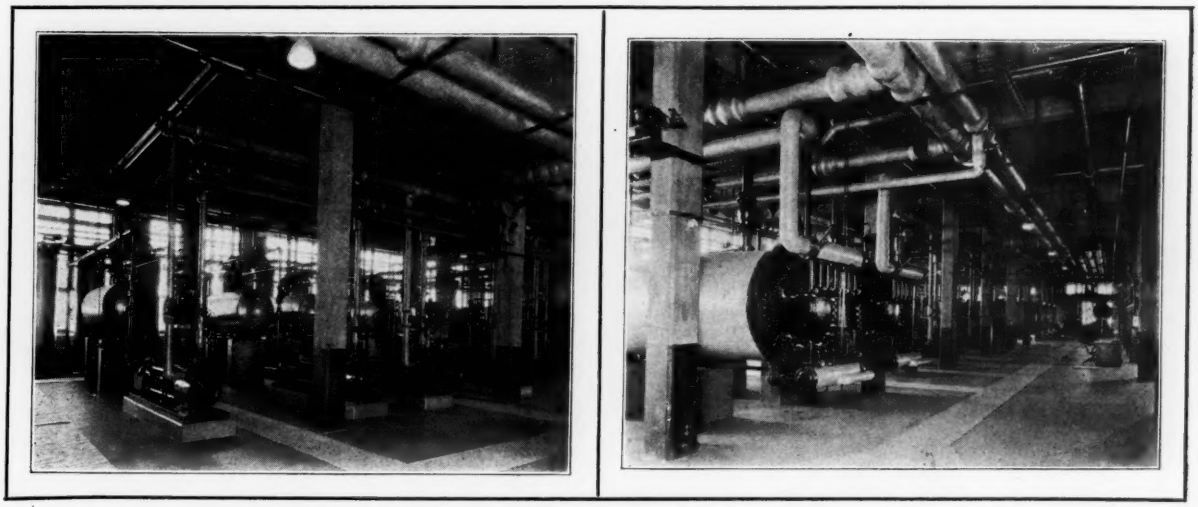


FIG. 2. VIEWS IN A LARGE ABSORPTION PLANT

It is not necessary to know the strength of the strong and weak aqua to determine whether or not the machine is sufficiently charged. If the conditions are met, the strength of the strong and the weak aqua will take care of themselves.

When the machine is first started, it is necessary to remove air frequently; but after this has been thoroughly drawn out of the machine, it is only necessary to do it two or three times in a season, provided that the machine is run day and night and the brine is not carried much colder than 10 deg. F. If a temperature lower than that is carried, the absorber gage will, at times, show a vacuum. In this case, air will be drawn through the stuffing-box of the ammonia pump, particularly if the drowning box is not kept full of water or castor oil. Under these conditions it is necessary to remove the air frequently. If the drowning box is kept filled, the stuffing-box is effectually sealed.

If the condenser coils are clean and there is ample water supply and yet the generator pressure remains high, it is an indication that there is air or non-condensible gas in the high pressure side of the machine.

This air can be drawn out, to a certain extent, through the bypass between the condenser and absorber, by opening the valve slightly from time to time while the machine is in operation. It is not, however, as satisfactory as shutting the machine down and drawing the pressure off the condenser and rectifier. This is done by shutting the steam off the generator and closing the valve between the generator and rectifier on both the gas and drip lines, also closing the valve on the cooler gas line and the valve between the condenser outlet and the anhydrous receiver. If aqua ammonia is circulated through the absorber and generator by means of the ammonia pump and the bypass between condenser and absorber is opened, a vacuum will be formed in the rectifier and condenser and the air drawn over into the absorber. When the machine is again started, the valve on the rectifier gas line should be slowly

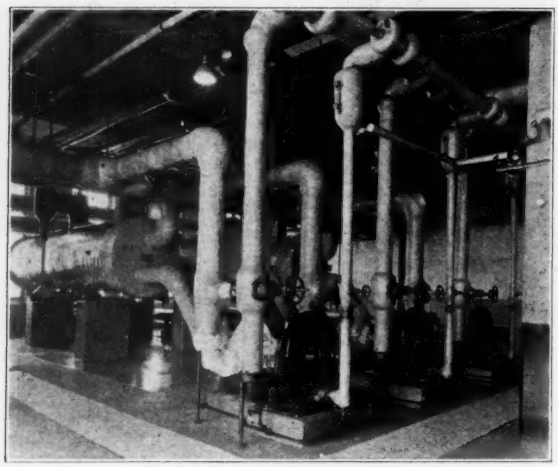


FIG. 3. BRINE COOLERS AND CIRCULATORS IN A LARGE ABSORPTION PLANT

opened until the pressures in the rectifier, generator and condenser equalize, then the rectifier drip line valve can be opened. Care must be exercised in opening the valve on the rectifier gas line, for there is a possibility of carrying aqua over into the rectifier and condenser in the same way that water is carried out of a boiler if the steam is drawn out too quickly. The valve between the condenser outlet and the anhydrous receiver can be opened, steam turned on and the machine put into regular operation.

Another way to remove air from the high pressure side while the machine is in operation, is to open the expansion valve wide. All the condensed anhydrous liquid will pass over into the cooler and the flow of gas then created from the generator to the cooler will oftentimes carry the air along with it, and allow it to collect in the absorber. This blowing process should be resorted to for 10 or 15 min. at intervals of a couple of hours and many times will serve to clear the high pressure side of air and non-condensible gases. It is recommended, however, that as soon as evidence of air disappears, this blowing process be discontinued. For the most efficient operation of the machine, nothing but liquid anhydrous should be fed to the cooler.

To get air out of the absorber in the most thorough manner, close the valve on the cooler gas line, also the expansion valve; stop the ammonia pump, but keep the weak liquor valve partly open and allow the liquid to rise in the absorber. The liquor will absorb all the ammonia gas in the shell or coil, but not the air, which is compressed by the rising liquid. When the absorber pressure begins to rise, the gas having been all absorbed by the weak liquor, the air can be blown out through the air vent on the absorber into a bucket of water until the liquor begins to come. At this point, the weak liquor valve should be closely throttled and the absorber pressure watched as it rises rapidly and should not be allowed to exceed 100 lb. The air valve should now be shut off, the absorber emptied by starting the pump, the cooler gas and expansion valves opened again and the machine started up in regular operation.

To get good results it is important that the condenser, absorber, weak liquor cooler and rectifier coils be kept clean. With ordinary river water the coils should be cleaned once a month and with muddy water once a week or oftener is necessary. In the shell and coil type condenser and absorber the coil tails are provided with valves. To clean any one absorber coil, shut off the valves and take the plugs out of the tees on the tails of that coil; attach a steam hose to the top tee; turn on the steam for about two minutes, then shut off the steam and open the upper coil tail water valve for about a half minute. This will produce a water hammer and the scouring action of the water will thoroughly clean the coils, dirt, scale and sediment being blown out of the bottom tee. The operation should be repeated several times.

When cleaning the coils of the shell and coil condenser it is absolutely necessary to shut down the machine, cut out the condenser, drain out all anhydrous ammonia into the cooler, and relieve the pressure through the bypass line into the absorber. Then proceed to clean the coils as in the case of the absorber. If any anhydrous ammonia is left in the condenser, the heat of the steam would cause it to boil and raise the pressure to such an extent that joints are liable to leak or even to rupture the shell.

Purging the cooler may be done as often as once a week and then again not for three months or four months. If there is lack of capacity not attributable to other causes and the gage cocks on the cooler are frosted as with a normal charge, the cooler needs purging. Another symptom is the cooler pressure which may drop 2 or 3 lb. if purging is needed. The purge line is also apt to be frosted when purging is necessary. although this can also be the result of feeding to much anhydrous ammonia through the expansion valve. If on opening the cooler gage cocks the liquor looks watery and sluggish, this is another indication. All of these signs point to the fact that some aqua has worked into the cooler and must be removed.

To remove this aqua or to "purge the cooler," close the expansion valve and let as much of the gas as will work through the cooler gas line. After about 15 min. close the valve on the cooler gas line and open the purge valve. This will drain all of the liquor out of the cooler into the absorber. The pressure will rise in the cooler at first, but after a few minutes will gradually fall. During the purging the ammonia pump should be run slowly and the liquor be allowed to accumulate in the absorber, or the aqua receiver as the

case may be. This will prevent the pump from losing its suction and becoming gas bound. During purging it is important that water be kept circulating through the absorber and weak liquor should also be circulated.

When the cooler has been well drained out, open the expansion valve for about a half a minute. This will increase the pressure slightly and force the remaining liquor out of the cooler. When this process has been repeated two or three times and the cooler pressure drops back to zero, the cooler has been completely purged and the machine can again be placed in operation. The purge valve should be closed and the cooler gas valve opened, care being taken not to open the expansion valve too wide at first.

Check Valve Discs Cause Trap Failures

By H. A. Jahnke

TILTING traps used for boiler feeding and other purposes are liable to give much trouble if not kept in first-class condition always. This statement applies to the trap and its pipe connections, such as the steam connection from the boiler to the trap and the discharge from the trap to the boiler, stop, check valves, etc., also the exhaust or vent line must be looked after frequently, that all may be clear to prevent trouble.

I have used tilting traps for boiler feeding and other purposes for a number of years. In most instances I overcome trouble in one way or another before it is necessary to shut down the plant on account of the water going low in the boilers, due to trap trouble.

Not long ago I had trouble with a tilting trap used for boiler feeding, which had me guessing for some time before I discovered the cause. It had been noticed recently that the trap was beginning to operate much slower than usual with the water supply valve wide open and the water in the boiler going lower every minute. I examined the trap from one point to another a number of times until I finally discovered that the trouble lay in the exhaust line of the trap. The exhaust from this trap discharges into a hot water tank and the pipe is arranged as shown in Fig. 1. To prevent the trap from siphoning any water from the tank a swing check valve is connected into the line, as shown.

In watching the trap I noticed that it took a long time for the pressure in the trap tank to release so it came below that of the water pressure after the trap tank came back to the filling position, hence I came to the conclusion that the exhaust line was not entirely clear or that the trap's steam valve was leaking badly. I examined the steam valve first to find whether it leaked, but this was not the trouble. Then the exhaust line was disconnected from the tank to the trap to find if this was clear. The cause of the trouble was found to be in the swing check valve in this line, as the disc which was of brass had come loose from the hinge connection and was wedged solid into the screwed opening of the valve, as shown at A in Fig. 1, and about the only place the exhaust could escape was through a ¼-in. hole in the center of the disc, as shown at B. The check valve is 1½ in., and we may imagine the time it took for all the steam to escape through this small hole before the pressure in the trap tank came below that of the water pressure. The steam pressure in this instance is 118 lb., while the water pressure is about 30 lb.

In another instance, it was noticed that it took much longer for the trap tank to empty before it returned into the filling position again, and was just about able to furnish sufficient water to the boiler. At first it was thought that the feed pipe from the trap to the boiler was beginning to clog up at some point. At the next boiler cleaning the feed pipe was examined and found clear; but the trouble was due to the fact that the re-

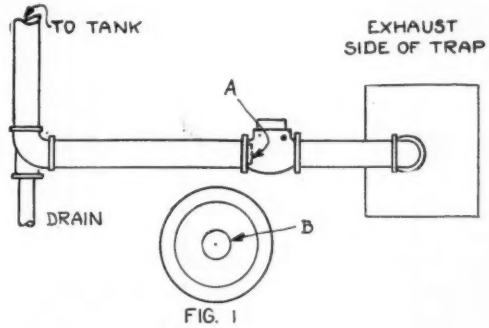


FIG. 1

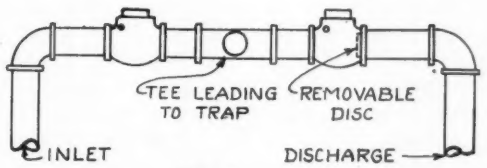


FIG. 2

FIG. 1. LOOSE CHECK VALVE DISC IN EXHAUST PIPE FROM TRAP

FIG. 2. DISCHARGE LINE FROM TRAP CLOGGED BY LOOSE REMOVABLE CHECK VALVE DISC

movable disc in the swing check valve on the discharge side of the trap had come loose from the disc holder, as shown at A in Fig. 2, thereby partly clogging up this end of the valve, hence the water could not pass through as quickly as when the passage is clear. Removing the disc from the opening and placing a new disc in the check valve remedied the trouble.

Iron Poles

A SHIPMENT of iron telegraph poles goes to South America, read the headline. We were wondering why, but a peep into J. Arthur Thomson's excellent book, "Outlines of Science," answers our query. Wood is abundant and cheap, but wooden poles would soon be destroyed by the powerful jaws of the terrible white ants!

In Ceylon, black army ants march on the warpath. A scientist counts them, finds 300,000 soldiers in one army, marching in companies about 20 abreast, with officers running up and down the line keeping order. Let a horse or man break a leg and fall in the path of the army ants, and in a few hours only a skeleton is left!

J. B. Dillon.

THE FELLOW who fights another's battle usually gets into trouble.

Chart for Selecting Steam Pipe*

By W. F. Schaphorst

WHILE MANY pages have been written during recent years on the subject of steam charts and formulas, unfortunately both the charts and the formulas are usually more or less bewildering.

In the accompanying illustration is shown the result of an effort by the writer to make a chart as simple as possible—a chart that requires only one operation for the solution of the problem and one that is based upon the velocity of steam that is used most, namely, 6000 ft. per min.

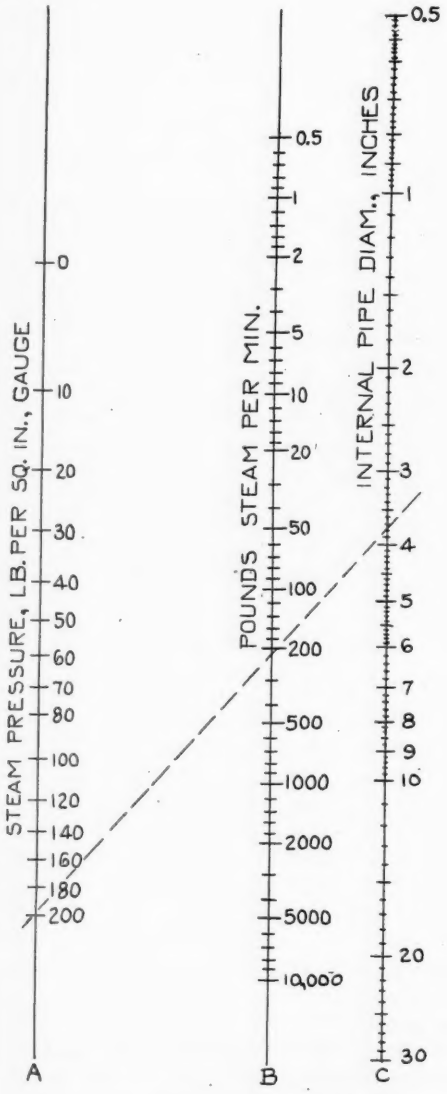


CHART USED IN DETERMINING PIPE SIZE

For example, what size steam pipe shall be used where the steam pressure is 200 lb. gage and where 225 lb. of steam are to be used per minute?

The dotted line across this chart shows how easily it is done. Simply run a straight line through the 200 column A and the 225 column B and the intersection with column C gives the answer as 3.82 in. internal pipe diameter. This is very close to a 4-in. pipe, therefore a 4-in. pipe would be used.

If the steam pressure is known (column A), and the pipe is already installed, the diameter of course is a known quantity (column C) and the pounds of steam that the pipe will carry per minute is easily determined by simply connecting the known factor in column A with the known factor in column C, and the intersection with column B gives the pounds of steam per minute.

This chart will be found satisfactory for most short pipes where the pressure drop is very small, amounting to only 2 or 3 lb. and is consequently almost negligible. Most steam pipes are short, therefore it is unnecessary to worry about the complexities to be found in most of the steam flow formulas commonly seen in print.

This chart is based upon the following simple rule, which may be used for checking purposes or for working out the problem in long hand if the reader prefers to use pencil figures rather than the chart. The rule is: "Multiply the internal diameter of the pipe in inches by itself, then multiply by 32.9 and then multiply that by the weight of one cubic foot of steam at the pressure used." The result is the pounds of steam per minute that will be carried by the pipe. The weight of steam per cubic foot may be found in most engineering handbooks; however, rather than go to the trouble of looking up these weights, for short pipe installations where absolute hair breadth accuracy is not essential and where 6000 ft. per min. velocity is satisfactory, this chart will serve the purpose very well.

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Combustion of Sawdust

Burning of sawdust for boiler purposes is best accomplished by means of a simply constructed "Dutch-oven" furnace, according to the United States Bureau of Mines. As a rule only one feed hole in the roof of the furnace is used, for sawdust is such an excellent fuel that it will produce a hot fire even when handled roughly and carelessly. Of course, with a single feeding hole in the top of the Dutch-oven, the sawdust forms a cone on the grate surface. A cone is about the least effective form in which any fuel may be arranged on a grate for burning. The draft penetrates the bed of fuel at the points of least resistance, that is, at the shallowest parts; hence the air enters at an excessive rate around the edges of the cone while the largest part of the grate is effectively airtight and consequently is "dead." This difficulty can be reduced or eliminated by different methods, which are described in Technical Paper 279, just issued by the bureau.

According to reports made to the Bureau of Census the value of products of establishments engaged primarily in the manufacture of fuel amounted to $3,178,000 in 1921, as compared with $1,974,000 in 1919, and $863,000 in 1914, an increase of 61 per cent from 1919 to 1921, and of 268.2 per cent for the 7-yr. period 1914 to 1921. The industry includes establishments engaged in the manufacture of briquettes from bituminous coal and anthracite dust mixed with tar and pitch as a binder; a composition of charcoal, pitch, tar, and sod; also fuels made of crude oil and sawdust, etc.

Pulling Together

By Jack L. Ball

DO YOU often meet men that work only for the wages that they receive? I have met a few and they are the most dissatisfied, restless, and I'd like to add, the most worthless chaps in existence.

Assume that you as an engineer step into your engine room with a feeling that you wish that the day was already ended. The equipment holds nothing that fascinates you. No doubt a great many problems are confronting you that, if you would solve them, would save money for your employer. But why borrow trouble when you can get by anyhow? You perform your duties in a desultory manner because you have to do something for the dollars that are paid you. Perhaps the rest of the crew feel and do as you do. Can you visualize a plant operated in such manner?

There are a great many persons of this type, if we but knew or had the time to look them up; but I know of one in particular. There various duties are done from routine or extreme necessity. Nothing ever varies in this plant except in case of a breakdown. Talk to any member of the crew and he'll give you the record of the other chaps. These men do not boost, try to help each other or even offer suggestions pertaining to the work. That would be a waste of time and, anyhow, wages are paid on pay day. The spirit of pulling together is wanting.

Space does not permit a character delineation of all the chaps, but here is one of them. I'll call him "John Smith."

John is the day fireman. He gets the same rate of pay as an engineer and is supposed to work two hours more. He always, however, comes into the plant twenty minutes to a half hour late. He offers no excuses for his tardiness. He is a boisterous chap with no friends. He is a very diligent student of the magazine sections of Sunday newspapers, but he never looks at an engineering journal. "Why?" he says, "I make more money than the engineers, so what's the use?" It is evident, then, that he measures his success in dollars, a common mistake.

Smith's job isn't hard, so he has quite a lot of spare time to tidy up the boiler room; but he doesn't. Valve stems leak at times but he says that it isn't his place to pack them; his job is to hold a certain steam pressure, that is, within 15 or 20 lb. He begins the day with clean fires, the floor in a somewhat decent state of cleanliness, pump lubricators filled and fire tools in their proper places. In the evening he puts on a heavy charge of coal, gets the boilers "popping" so that he can quit 15 or 20 min. early. So many hours, so many dollars. His relief gets paid for his time, so it doesn't matter how things are left. The job holds no fascination for him. Again the spirit of pulling together is found wanting.

Now this chap will have a job just as long as he can "hold steam." He may, of course, encounter some unforeseen obstacle as Napoleon did at the Battle of Waterloo. Some day a progressive company may take over this particular plant. It will be hard for this fireman to change from the old order to the new, for habits of years are not easily put aside. A spirit of co-operation with his fellow workmen, however, might help him to tide over the difficulties because someone might boost him, try to help him along.

Somewhere in history we read where Hannibal was crossing the Alps with his army. Finally the army was halted because no man of the advance guard could cross a certain swollen stream. The general rode to the front, summoned his soldiers and ordered them to "join hands by fifties and march across." The army forded the stream without the loss of a single man.

This illustrates mutual confidence and the reward of pulling together, an essential requisite that is necessary in the successfully operated power plant, a place where jealousy, indifference, selfishness, opposition and a multitude of things that disrupt harmony and co-operation are out of order.

A New Refractory Material

EXPERIMENTS which have resulted in the production of a new resistant material to which the name "quartzilite" has been given are described in a bulletin of the Association Suisse des Electriciens, and also the Electrician of Aug. 11. This substance is made by means of a mixture of quartz and carbon, at a temperature between 3600 and 5400 deg. F. It has a crystalline structure, and it can be made in the form of rods, tubes or plates, although the latter form has not been found quite satisfactory. It will resist temperatures as high as 3400 deg. F. soon after which it begins to oxidize. It resists moisture well, will not crack when watered hot, and can even be kept in a state of incandescence, in service, under water.

One difficulty which has not yet been overcome is the making of suitable electrical connections where this material is used as a resistance. The parts of the rod or other element in contact with the current will have to be made of less resistance than the remainder in order that it may not be heated to incandescence.

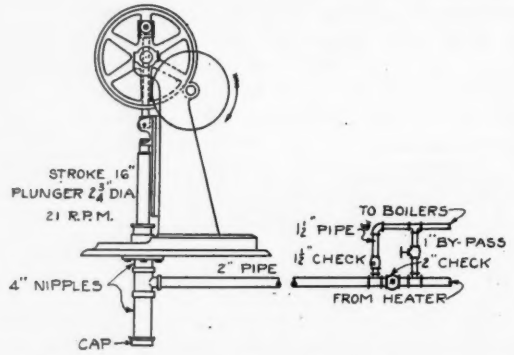
Quartzilite has a small coefficient of expansion, which is an advantage in the case of electrical connections. The curve giving the resistance values in function of its temperature shows that heating from 0 to 1080 deg. F. brings down the resistance to about one-half its original value; beyond 1080 deg. F., it increases 5 per cent, after which it again diminishes. This seems to indicate that the material can be most advantageously used at temperatures between 1080 and 1800 deg. F. It seems probable that this new compound will be valuable in all applications where high temperatures by means of electrical resistance are involved, and it is expected to be especially suitable for medical purposes.

TESTS ON THE 20,000-hp. Pelton single overhung reaction turbine at the Cedar Falls extension plant of the City of Seattle have just been completed. This plant was placed in service in June, 1921, but for reasons beyond the control of either the city or the manufacturer, final testing was delayed until a few days ago. Notwithstanding having been in service for more than a year and a half, the unit was found to be in perfect operating condition, the absence of vibration being particularly noticeable. Water measurements were made by a weir installed permanently as a part of the power plant equipment. A very satisfactory efficiency curve was obtained, the maximum exceeding 92 per cent.

Reciprocating Pump Without Valves

On account of the reasonable first cost, reliability and convenience of installation, a direct acting duplex steam pump is generally selected for feeding boilers, especially in small and medium sized plants. These pumps, however, are inefficient in the use of steam, and require considerable attention and expense to operate.

If one water piston is packed tighter than the other, the pump will short stroke on one side, increasing the clearance in the steam cylinder, resulting in an increase



BELT DRIVEN PUMP IN THE BOILER ROOM HAVING BUT ONE PIPE CONNECTION FEEDS WATER FROM HEATER TO THE BOILER WITH MINIMUM OF HOT WATER PIPING

in steam consumption. Considerable leakage may develop around the water pistons before becoming noticeable, and on account of the difficulty of repacking, is generally allowed to become serious before being taken care of; and this further increases the amount of steam used, as the pump must be speeded up to supply the necessary amount of water. In a great many cases, a belt driven outside packed plunger pump presents a satisfactory solution of the boiler feed problem, and has none of the serious objections of the steam pump.

The greatest difficulty is in securing a drive for the pump without installing it at a considerable distance from the boilers. Ordinarily this means a long suction pipe from the source of supply, and a long discharge pipe from the pump to the boilers. If the supply is from a heater, there will be a loss of heat by radiation from the pipes, which overcomes, to a large extent, the advantage gained otherwise.

Some time ago, the writer installed a power pump in a novel manner and the results were so satisfactory that a description of the installation may be of interest. The accompanying sketch showing this pump is almost self-explanatory. The deep well pumping head which was adapted to the purpose was set just back of the main shaft of a Corliss engine and belted from a split wooden pulley. As will be noticed, only one pipe was run to the pump, which was 45 ft. from the duplex pump, used for boiler feeding before the one under discussion was installed. Two check valves were provided as indicated and a bypass valve provided for regulating the amount of water pumped into the boilers, the speed of the pump being, of course, constant. Comparing the plunger area with that of the 2-in. pipe, it will be seen that the water entering during the upstroke of the plunger would travel a distance of only about 2 ft. 8 in. toward the pump, so that the heat lost by radiation would be small.

Packing a pump of this description is a simple matter, and any leakage can be detected and stopped immediately, without interfering with the operation of the pump. No special packing is required when pumping hot water, as the water being pumped does not come in contact with the packing. There are no steam cylinders to lubricate, so the trouble of filling a lubricator, and the expense of cylinder oil, are eliminated.

Oil and packing necessary for this pump was estimated at $2 a yr., and the check valves were still in good condition at the end of 18 mo. service. As a matter of fact, the installation of this pump resulted in an actual saving of $25 a mo. over the duplex pump previously used, and the entire cost, not including labor, which was done by the regular force, was less than $75. The pumping head was purchased, secondhand, for $40. As a safety measure, the duplex pump was left in place to be used in case of an emergency. Altogether it was an entirely satisfactory installation, and was popular with the men, owing to the ease with which the amount of water pumped into the boilers could be regulated, and to the absence of packing and lubricating troubles.

Phoenix, Ariz. S. B. Richey.

Employ Engineers for Engineering Work

Dear Mr. Millowner:

Good morning! Maybe not so good, after all. Perhaps you went home last night with a nice grouch on and still have it with you now. Oh, you have had it for several days? All about what? It's not hard to guess. S'pose some little mechanical trouble down at the shop has got you all upset. Yes, these little problems are bound to arise, they come to the fellow with the big concrete factory just the same as to the fellow in the rented loft—the only difference is that they have found out how to overcome the difficulty and you have not.

Where do these troubles show themselves? They don't as a rule. They simply play hide and seek with your production and your profits. Let's take down the veil for a moment and look right at it. A poorly heated room, a poorly lighted work space, dirty toilets, slovenly

kept wash rooms, slow elevators, wrong application of motors, etc., all go to making up the unattractive picture that you avoid.

Now say it. You knew all about this and that and perhaps have spent hundreds of dollars tinkering with the situation, and still it is not right. That's natural; certainly it is not just right; you have only been playing with the situation. You have, no doubt, applied your whole hand in a clumsy fashion where the deft finger of the expert was sadly needed. Don't get sore at these truths. You did everything for the best and have gotten nowhere. You probably make piano cases, bed springs, candy or some other commodity and are an expert in any of these lines of endeavor; but you fooled yourself when you took on being master mechanic for your plant. And you fooled yourself again when you called in the electrician, the steam fitter, the plumber and others to tamper with a situation that required the same degree of expertness that you apply to the moulding of your business policy.

Just because you have everyday contact with the utilities in your plant or shop, don't think that you can treat them with contempt. Sure, the electrician can do wiring, the steam fitter can do pipe fitting and the plumber can wipe joints, all far better than you or I; but the treasured mission of these good fellows lies not in knowing "why" but "how."

If you think you have a fever, you don't fool with it; you call in the doctor for a diagnosis. Yes, then you take his prescription to the druggist, have it filled, take your medicine and in short order you're back on the job. But you don't apply the same common sense to the place where you get your bread and butter and golf-stick money.

What should you do? Why, get an engineer who is capable of making a diagnosis of your mechanical troubles; he is comparable to the doctor. Respect the engineer's report and call upon a good contractor to execute the engineer's recommendations to the letter. The contractor is comparable to the druggist. As a rule, when this procedure is followed the troubles about the shop fade away.

Until you make your decision, you are on shaky ground. How's that? Why, you can do what lots of foolish people do, you can throw the doctor's prescription into the sink or the engineer's prescription to the wind and then turn around and ask the contractor whether he knows a better way to do the job. If the contractor is onto his job and any kind of salesperson, you will be sold a cheaper way to do the work. Just like the druggist, he does not object to selling you patent medicine, provided you buy enough of it and he only hopes that you live long enough to buy more of it.

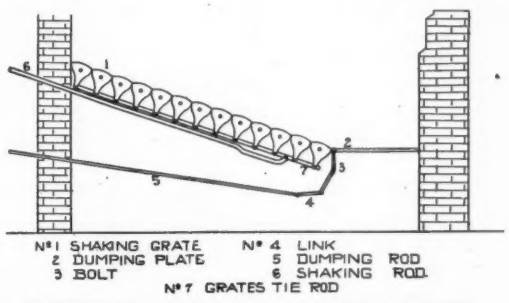
The truth is, none engaged in the art of patching up work will ever root for making clean sweeps of old methods and dilapidated equipment. These patchers thrive on the weakness of the management that finds consolation in tinkering. My, how they enjoy their gloom!

I hope I haven't hurt your feelings, Mr. Millowner, and trust you will come back next time for more. Before you get away listen to this. Yes, sir, I knew you were going right down to the engine room to vent your feelings; you blame a lot of things on him. You've got a pretty good man down there and he is trying to get the most out of your coal pile, but let him be. He can't get kilowatts out of the coal pile and rags out of the stuffed-up plumbing pipes, and fix the house tank, and run new wiring on the fifth floor and wash your car all at the same time. Do you get it? And say, Mr. Millowner, if you see the light now, turn it on full; it's the cheapest kilowatt you ever found.

Good night,
F. C. V.

Saving Effected by Converting Flat Shaking Grate into Semi-hand Stoker

I HAVE in charge two 78-in. by 18-ft. horizontal return tubular boilers that are 30 in. above the grates. We have always burned a good grade of soft coal without a great deal of smoke, but the late scarcity of coal compelled us to use almost anything we could get if we were to keep up steam. This coal was high in volatile matter and caused intense smoke with the setting we were using. We consulted a few specialists on combustion and were advised to put in hand stokers so as to



SECTION OF HOME-MADE SEMI-HAND STOKER

give more furnace volume, but we found on investigation that the cost of such a stoker was more than the company was willing to pay, so the matter was dropped temporarily.

On giving the idea more consideration, however, I came to the conclusion that I could make a semi-hand stoker, by removing three shaking bars at the back and substituting a dumping plate and by inclining the grate about 3 in. to the foot, which would give more furnace volume.

One day, I approached the manager with this idea and asked if I might get two cast iron plates and the other necessary things that were needed to make the stoker. The answer was to go as far as I liked. I had a pattern made and a piece cast at a local foundry, and in two weeks' time everything was ready to install. When the time came for our annual shut-down for inventory, my grate was put in. On firing this boiler up we found that it was a whole lot better and more economical than the other and in six months we had the two boilers equipped. A saving of fuel amounting to from 20 to 25 per cent was immediately noticed in the plant. We fire those stokers the same as we did the flat grates. We have tried all methods of firing and this has proved the best in our plant. The accompanying sketch will give an idea as to what the grate is like.

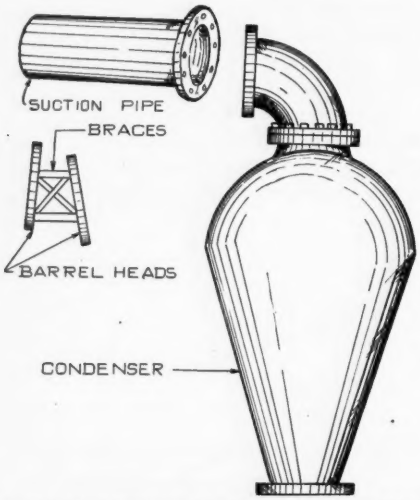
Three front bars are held stationary so that they will not shake unburned fuel in the ash pit. Two or three rear bars are removed, considering, of course, the size and make of the grate and a dumping plate was substituted with a series of holes 1 to 1¼ in. in diameter

for air. On each end there is a pin of proper size, for supporting the plate, also on each end of plate, there is a flat head bolt for attaching the dumping rods. The remainder of the shaking bars are tied together so that they can be put up at small cost.

Winsted, Conn. T. D. T.

Crooked Pipefitting

In connecting up a condensing pump in a street railway plant in New Jersey, the suction pipe was found to be over 3 in. out of line, and at an angle with the 12-in. elbow at the top of the condenser. Owing



PATTERN FOR CONNECTION FOR MISALINED PIPE FLANGES

to the iron work in the building construction, the suction pipe could not be straightened; neither could the elbow on the condenser be moved.

To make some sort of connection, a man from the engineering office came to take measurements for a "Dutchman". This was made, but it was a sad misfit. The boss steam-fitter then obtained two small barrel heads. One was placed against each flange and braces nailed between them, as shown in the accompanying sketch. The inside and outside diameter of the flanges, and the boltholes, were scribed on the barrel heads, and the pattern set to the foundry.

When the casting came back, it was found to fit perfectly. M. M. Brown.

Tempered Coal Is Not Suitable for Underfeed Stokers

Mr. Marsh's remarks on tempering coal with water as an aid to combustion, in an article on page 215 of the Feb. 15 issue, are true as far as concerns hand firing and overfeed stokers, in which he is chiefly interested, but it does not hold for underfeed stokers. In such stokers wet coal is a decided detriment. I have tried wet coal often, although usually involuntarily, on both multiple and single retort underfeed stokers of all types and the universal tendency is to pack the coal into a hard mass that resists coking and the opening up of the fuel bed for rapid uniform combustion. The result is an accumulation of a heavy mass of green coal just inside the front wall that will not feed back properly and which cannot be broken up by the agitation available from the stoker mechanism. Water may get into the coal in various ways as from rain, leakage of barges, and dripping of pipes into bunkers or hoppers, but apparently the wetness produced by snow being brought in with the coal causes the most exasperating trouble, probably because it produces the most thorough wetting.

I recently investigated a complaint that a coal of excellent quality would not work well on a first class single retort underfeed stoker and found that part of the trouble was due to the coal not feeding back and giving a thin fire on the rear of the grate, and that this was caused by sweeping up wet siftings from the floor and refiring them through the stoker hopper. Changing this to refiring them direct through the observation door eliminated that part of the trouble.

In addition to troubles in the fire box, wet coal more than doubles the work of the fire room force by sticking in bunkers, chutes and hoppers and requiring constant poking and shaking to keep it loosened up and moving. In fact, I have often seen it require a man to every hopper to keep the coal poked down in front of the rams. While hopper agitators are usually a source of some trouble under such conditions, they are worth almost anything.

In a recent book by a reported authority on stokers and their operation, wetting coal for underfeed stokers is said to improve the fuel bed and give much better combustion, but after a thorough tryout on rather fine semi-bituminous eastern coals I can testify that wetting such coal is a detriment rather than a help.

Colver, Pa. A. D. Fisher.

A Man's Title Does Not Describe His Ability

I read with some interest the articles in the Nov. 1 and Dec. 15 issues concerning the relationship of the chief engineer to the master mechanic. The trouble, as I see it, is a personal one in each case. It all depends on the individual concerned. In this respect, I would like to mention some experiences I have had.

I hired out one time as a mechanic, under a chief engineer. At this plant the main unit is a 1250-hp. Corliss which had a peculiar groan at slow speeds when starting and stopping. I stood listening to it one noon, and the C. E. said to me, "What do you think is the matter with her?" I answered that the crankpin hole was probably out of square with the brasses, for, which opinion he gave me the Ha! Ha! A few weeks later we shut down for repairs. I put the brasses in the lathe and found them, as I said, out of square. I set the brasses up as they should be, rebored them, and put them back. Eight years have passed since that time, without a groan. The C. E. told the general manager that he discovered what was the matter with the engine.

One time I was sent into the logging woods to look over a locomotive. I was told to take a flue roller, as the flues were leaking badly; also to take some valve grinding compound to grind the valves with. (Now, what do you think of that?) After a long journey, I arrived at the spur where the logging road met the main line; from here I carried my case of tools, includ-

ing the flue roller, through the deep snow for a distance of 8 mi. to the camp where the engine was tied up. Next morning, after a fine camp breakfast, I gave the locomotive the onceover. We filled the boiler by the hand-to-hand method out of the creek, which was no small job, then started to raise steam.

I asked the engineer what was the matter with the steam gage, as it wasn't registering.

He said, "I don't know."

I asked him if he didn't take it off and drain it when he tied the engine up. He said he hadn't, and didn't know it was necessary.

I asked, "What pressure does your safety valve pop at?"

"I don't know," was his reply.

By this time the thing was beginning to sizzle pretty well and I began to think that perhaps it was about time to hit for the tall timbers, but the safety soon popped and I felt somewhat better.

"What's the string on the throttle lever for?" I asked, and he told me that if he didn't tie the thing, she'd start down the track.

I opened up the fire door, and water was running out of nearly every tube, and out of the front of the smoke box onto the ground. I followed up the pipe he was blowing up steam with and found he was using the steam brake instead of the blow pipe. This exhausted into the side of the smoke box where it condensed and ran back through the flues. As soon as this line was cut off and the proper one used, the flues stopped leaking. And to think I had to carry that flue roller back eight miles through the snow!

I found the flues half filled with soot, and one half of the nuts off of the braces and bolts under the engine and tender.

Now, these two men mentioned were both supposed to be engineers and went with that title; but they were, nevertheless, not engineers in the true sense of the word. It is not the man's title that accounts for his actions, but rather the man himself. There are good master mechanics as well as poor ones, just as there are good and poor chief engineers, or doctors, or lawyers, or anything else. L. E. H.

Regulating Return Water

AFTER READING M. M. Brown's article, page 190, Feb. 1 issue, on "Assumption," I might relate the following.

I have similar conditions in regard to makeup water but I obtain better results than those Mr. Brown describes.

My returns from various traps discharge into a vented receiver tank 30 in. diameter by 8 ft. long. I have a Webster vacuum system of heating and all returns are taken care of by a vacuum pump and discharged into the receiver tank. Since the tank and pump are set below the lowest coils, I sacrifice my vacuum but by judicious manipulation of the makeup water to the vacuum pump I can maintain a fairly constant water level and put water into my boilers at 200 deg. F and sometimes as high as 210 deg.

Although I sacrifice some vacuum and at times have 1 to 2 lb. back pressure which might slow up the travel of steam through the coils (live steam reduced to 5—7 lb.), it is evident that as long as the system does the required heating the sacrifice in vacuum is more than offset by the gain in the feed water temperature.

It had been customary to give the vacuum pump enough make-up water to maintain a vacuum of 3 or 4 in., the excess water going to the sewer and the temperature of feed water being kept down around 75 to 100 deg.

We purify all our water, which is used for all process work, domestic uses, and boiler feed. The extra amount of water used in winter time was enough to be noticeable but could not be accounted for, as it was reasoned that it could not be lost in the heating system since all returns were delivered back to boiler.

As our consumption about balances the purifier capacity for a day's run, it is necessary to conserve water and an amount like this is appreciable. Our Triplex pump sets about 2 ft. below the receiver tank, so very little trouble is experienced with vapor-bound pumps.

Although the pump is motor-driven and equipped with a starting and stopping switch, actuated by a float in receiver tank, I pay no attention to this, but keep the tank level constant, and regulate the feed to the boilers with a bypass on the pump. LEROY BLAKE.

Worcester, Mass.

Cement Wash as a Preservative

WE HAVE been troubled in the past with pitting in the drums of our B. & W. heating boilers until we coated the inside with a cement wash made from portland cement mixed with water to a thin consistency and applied with a paint brush.

The first boiler that was treated had two 48-in. drums 18 ft. long. It was thoroughly cleaned with scrapers and a wire brush. All small blisters were removed so as to get to the solid metal and the surface was then given two coats of the cement wash. It was such a success at the end of the heating season that three other boilers were treated the same way. That was three years ago, and the boilers haven't shown any sign of pitting since. The boiler inspector is perfectly satisfied. The boilers carry 100 lb. pressure. We leave the boilers dry in summer with the manhole plates removed.

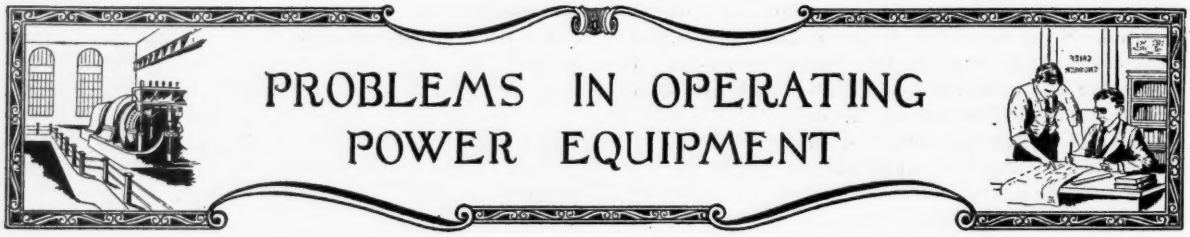
We also use it on the inside of elevator tanks, and it is excellent for the inside of hot water storage tanks for office buildings. THOMAS SHEEHAN.

Springfield, Mass.

Correction Notes

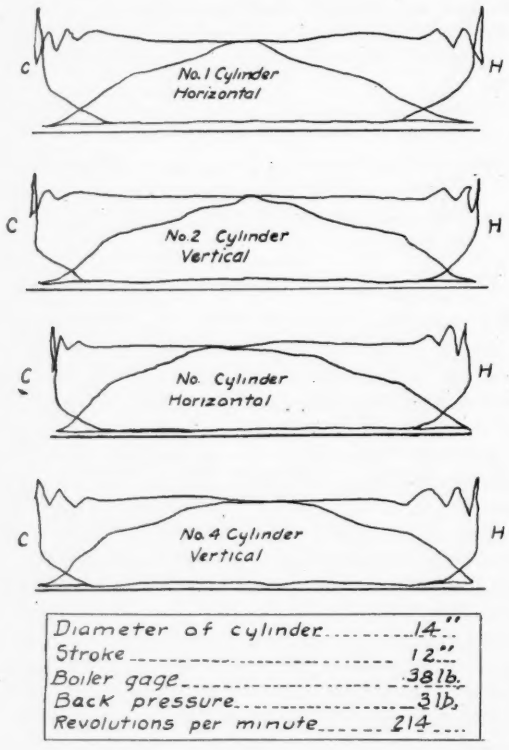
WE ARE advised by Mr. Summers, whose article "Change in Ammonia Piping to Simplify Charging" we published on page 193 of our Feb. 1 issue, that there is an omission in the drawing marked "B." There should be a valve in the charging line. The diagram referred to in the last sentence is diagram "B", and not "A" as stated.

Also, on page 175 of the same issue, in the article "Calculation of Power in Three Phase Circuits," by H. G. Roberts, in the eighth line from the bottom of the first column, the expression (sin 30 deg.) should read (— sin 30 deg.).



What's Wrong With These Cards?

I WOULD like to have the opinion of the readers of Power Plant Engineering on the accompanying indicator cards which were taken from a four-cylinder (two horizontal and two vertical) engine driving a paper mill. What is wrong with these cards? What



INDICATOR CARDS FROM A FOUR-CYLINDER PAPER MILL ENGINE

condition of the engine or indicator do they show? All cylinders are of the same size, 14 in. bore by 12 in. stroke, and work under identical conditions. The boiler pressure is 38 lb. and the back pressure is 3 lb. The unit operates at 214 r.p.m. C. B. F.

Would Reduction of Boiler Pressure Be Advisable?

WE HAVE an 80-hp. return tubular boiler that we use for heating and process work. Our power is electric. We now carry about 100 lb. of steam on this boiler. What would be the savings in coal if we carried 40 lb. pressure instead?

At another of our mills we have an 18 by 40-in. Hamilton engine running condensing, with a water-wheel connected to the same shaft. In addition to this we have a non-condensing engine that was intended to use as a standby. We find, however, that we have to run this almost regularly and it is, of course, not as efficient as the condensing unit. We now run the condensing engine at ¼ cutoff. If we increased the cutoff, would we get more power? If possible, we would like to change the condensing engine so that it will carry the load without compounding it. Would it be practical to increase the cutoff to ⅓, and if this were done, what per cent increase in power would we get and what loss in efficiency? J. P. O.

Use of Reclaimed Oil

WE HAVE a separator in our exhaust line, discharging condensation and oil through a trap into an arrangement where the water and oil are separated. This oil is then used again in the cylinders of our engines and pumps. We would appreciate any information regarding the lubrication value of this oil. Has the "life" been taken out of it the first time through or not? Is there any way it can be used, except for lubrication?

D. W. H.

What Change in Setting Would You Recommend?

WE HAVE in our plant here two 44 in. by 14 ft. tubular boilers which we have been trying to fire with a cheaper fuel such as North Dakota lignite or Illinois screenings, but without success. About the only coal which we have been able to get by with satisfactorily is Kentucky Elkhorn, run of mine; and the price is high.

Would it not be possible, by increasing our draft or grate area or both, to use the cheaper fuel? If increased draft would solve our problem, which would be better, forced or induced?

Possibly some other of your readers have been up against the same problem and have overcome it. If so, I would appreciate their comments. A. R.

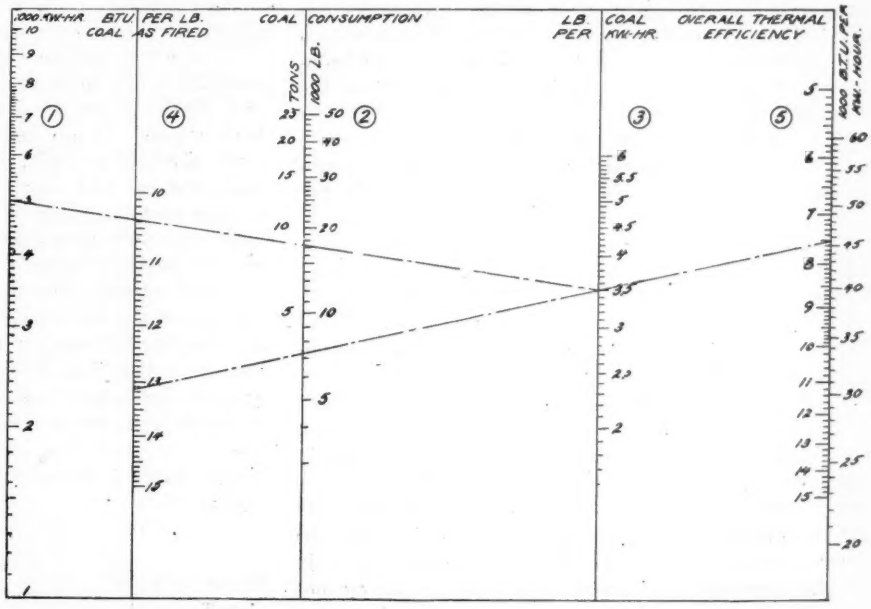
Coal Consumption Per Kilowatt-Hour

SOME TIME ago I noticed a chart for figuring the coal consumption per kw.-hr. for large steam plants. The lower limit of this graph was way beyond anything that would be reached in the way of kw.-hr. output per day for a small plant and so was useless for my purpose. Have you a chart available that will give this information for small sized plants? W. P.

A. For your convenience and for that of other readers who may be interested in this question, we have prepared the alinement diagram, shown in the accompanying figure, for finding the pounds of coal consumed and the B.t.u. supplied per kw.-hr. developed also for finding

the net overall thermal efficiency of the plant from coal-pile to switch-board.

Five scales are used. Scale No. 1 is the output of the plant in a given time, in 1000 kw.-hr. Scale No. 2 is the coal consumption in the same time. On one side it is given in tons and on the other in 1000 lb. Scale No. 3 is the coal consumption in pounds per kilowatt-hour. Scale No. 4 gives the heating value of the coal as fired. Scale No. 5 is really two scales, the one to the right shows the heat consumption in 1000 B.t.u. per kw.-hr. developed and the one on the left indicates the net overall thermal efficiency of the plant in per cent.



ALINEMENT DIAGRAM FOR DETERMINING COAL AND HEAT CONSUMPTION PER KILOWATT-HOUR OUTPUT, AND OVERALL THERMAL EFFICIENCY OF PLANT FROM COAL PILE TO SWITCHBOARD. WHILE THIS CHART IS DESIGNED PRIMARILY FOR RELATIVELY SMALL PLANTS OF 1000 KW. CAPACITY OR UNDER, IT MAY BE APPLIED TO LARGER CAPACITIES BY PRORATING THE QUANTITIES INVOLVED OVER A SHORTER PERIOD OF TIME THAN THE CUSTOMARY 24 HR.

Take an example. Suppose we are burning coal having a heating value of 13,100 B.t.u. per lb., that the electrical output for the day is 5000 kw.-hr. and that during this time 8.8 T. of coal were burned: With a straightedge on 5 on scale 1 and on 8.8 on scale 2, we find that the point of intersection on scale 3 is 3.5 lb. of coal per kilowatt-hour. Now with the straightedge on 13,100 on scale 4 and on 3.5 on scale 3 we find on scale 5 that the heat consumption is about 46,000 B.t.u. per kw.-hr. and also that the overall heat efficiency is about 7.6 per cent.

As scale No. 1 runs up only to 10,000 kw. hr., it will be seen that for a plant operating 10 hr. a day, the maximum capacity for which this chart can be used is 1000 kw. Under these same conditions the lower limit is 100 kw. installed capacity. If it is desired to use the chart for larger capacities it will be necessary to consider the kw.-hr. output and the coal consumption as over a shorter period or, what is better, prorated over a shorter period. Suppose for instance that we have a 1500-kw. plant that operates for 10 hr. a day. Suppose that during the day of 24 hr. the output is, say, 12,000 kw.-hr. and that during this time 25 T. of coal are consumed. An inspection of the chart will show that the figure for kw.-hr. output runs off the scale and that the coal consumption is at the limit of scale No. 2.

In this case the chart may be used by prorating both quantities on a 12-hr. basis instead of 24. This then will give an output of 6000 kw.-hr. and a coal consumption of 12.5 T., both of which figures are on the scale, and the process may be followed through as indicated.

In making a computation of this kind and arriving at certain efficiency figures, the conditions under which the data were taken should be borne in mind, so that the results may not be misleading. Obviously the performance of two plants can not be compared unless conditions are the same or unless allowance is made for the difference. For instance, an 8-hr. test of one plant cannot be compared with a 24-hr. test of another, in which coal consumed during banked periods is included.

Valve Setting for Vertical Engines

R. O. M.'s LETTER on page 243 of the Feb. 15 issue interests me. The following ideas may be of assistance to the correspondent and others who may be interested in the matter.

With large vertical engines of the marine type it is customary to give a greater steam lead at the bottom end of the cylinder, in order to bring to rest quietly the moving parts, viz.: the piston, piston rod, crosshead, and connecting rod. Not only is the weight of these parts to be considered, but also the inertia effects. The combined weight and inertia is greater at the bottom end in a vertical engine and so an elastic cushion should be provided to counteract the effects referred to. This may be done by increasing the compression at the bottom end, and further by increasing the lead. If it were not for the design of the valve (the ordinary slide or piston valve is here meant) upon which the movements of the value depend, no lead would be required at the top end of the cylinders.

As a general thing, the less lead and the less compression we give an engine, consistent with all considerations, the better will the engine run, and the least quantity of steam will be consumed to develop any given power.

Attempts have been made to determine just how much compression, and how much lead should be given to any given engine. These calculations are usually difficult and involved, and they are not exactly suited to the needs of the operator. In the past, operators have set valves which includes the proportioning of lead by the use of the indicator. Diagrams were taken, experiments were made with different valve settings, and results noted. The form of the indicator diagrams serves as a guide in making alterations in the valve settings. In marine practice it is usual to give twice as much lead at the bottom ends as that given the top ends. It does not seem to be a matter of mathematics with operating engineers, but instead a matter of judgment and choice, guided by the form of outline of the indicator diagrams and the smooth running of the engine. Allowance is also made for the possible rapid downward wear of the parts to which the valve is connected which will tend to increase the lead at the top end and decrease at the bottom end.

Perhaps rules and formulas could be derived from which the best leads for any given engine could be found. The same may apply to compression. But it is doubtful if operators would use such rules unless they were made so simple and easy to apply that time and trouble would be saved in using them.

The foregoing suggests something else in relation to the matter, and that is the balancing of the piston on the upward stroke against the weight and inertia of the various parts before referred to. The inertia forces are somewhat difficult to calculate and as there are inertia forces on the up stroke as well as on the down stroke, those on the down stroke are probably greater, due to the influence of the gravity. If we but consider the weight of the parts to be counterbalanced, we shall at least make a step in the right direction.

Let us assume a problem: The high pressure cylinder of a three-cylinder, triple expansion engine of the marine, vertical type, 16 in. diameter, 48 in. stroke, and 80 r.p.m., assuming that a mean effective pressure of 100 lb. is acting on that piston, and that the combined weights of the piston, piston rod, crosshead and connecting rod is 2000 lb. What horsepower is required to move that weight in the given time and space. The work done is $2000 \times 4 \times 160 = 1{,}280{,}000$ ft.-lb. per min. and power required is $1{,}280{,}000 \div 33{,}000 = 39$ hp. (nearly). Thus it is assumed that 39 hp. developed by that cylinder is required to move the piston and other parts at the stated speed, and that this power is required on the upward stroke only. If this be true, then the mean effective pressure should be greater at the bottom end to meet the conditions. The excess m.e.p. required at the bottom end is

$$39 \times 33{,}000 \div (4 \times 0.7854 \times 16^2 \times 160) = 10 \text{ lb.}$$

These two steps involved, i.e., finding first the horsepower and then the additional m.e.p., may be simplified as follows. The extra power required to raise the moving parts is

$$\text{hp.} = W \times L \times 2N \div 33{,}000$$

where W is the weight, L the stroke, and N the r.p.m. The m.e.p. required is found from the equation

$$\text{hp} = P \times L \times A \times 2N \div 33{,}000$$

where P is the mean effective pressure and A the area of the cylinder. By equating the right hand members of these two equations we have

$$P \times L \times A \times 2N \div 33{,}000 = W \times L \times 2N = 33{,}000$$

and by canceling like quantities on either side of the equation

$$P \times A = W$$

or $$P = W \div A = 2000 \div 200 = 10 \text{ lb.}$$

This would mean that the m.e.p. at the bottom end will be 110 lb. and at the top 100 lb. The valve setting, laps, leads and compression should be so adjusted as to obtain the desired result.

CHARLES J. MASON.

Brooklyn, N. Y.

ON PAGE 243 of the Feb. 15 issue, R. O. M. asks for information regarding valve setting on vertical engines.

In vertical engines, say of the marine type, it is generally found to be a matter of try and fit; however, with anything like equal the cutoff will be later on the down stroke. If any attempt is made to equalize the cutoff, the lead and port opening on top will become too small and the lead on the bottom excessive. With any attempt at equal leads on top and bottom, the points of cutoff will vary in the two ends by as much as 10 per cent or, perhaps, more. Similar derangements will result if an attempt is made to balance the exhaust. Better results can be obtained by not trying to balance any one item in both ends. The accompanying table from Dyson's "Practical Marine Engineering" shows proportions that result in good balance for vertical engines, under the conditions indicated:

VALVE SETTING TO GIVE GOOD BALANCE ON VERTICAL ENGINES

Steam opening	Bottom 0.7% before end of stroke	Top 0.4% before end of stroke
Cutoff	68%	59%
Exhaust openings	90%	91%
Exhaust closes	85%	84%
Steam lap	2.44″	2.40″
Exhaust lap	— 0.12″	+ 0.68″
Steam lead	0.60″	0.52″
Port opening for steam	2.08″	2.12″
Angle of advance	33°	
Throw of eccentric	$4^{15}/_{16}$″	

S. P.

Watt-Hour Meter Operation

IN THE Feb. 1 issue of Power Plant Engineering on page 195, L. L. P. asks concerning the operation of a polyphase meter in regard to the relative speed of the two elements.

Personally, the writer would not connect a meter of this type as shown in the diagram, but would install an additional potential transformer in the phase 2 leads of the generator. The potential transformer now under control of the double throw switch to be permanently connected to phase 1 bus. With this arrangement it would be possible to do away with the double throw switch, to use the one voltmeter, through suitable plug switch, and to obtain voltage readings on either phase of the bus or one phase of the machine about to be synchronized. The synchronizing of the machine could be done without making a primary circuit switch, as another suitable plug switch arrangement would enable the operator to handle this matter on the secondary circuits of the potential transformer proposed in the

phase 2 leads of the machine and the present potential transformer now in the phase 2 bus. This arrangement would prevent the danger of having the proper operation of the meter interfered with by the possibility of the switch not being properly reset after synchronizing. It would also serve to leave the synchronizing lamps out of circuit except when they are in use to put the machine on the bus.

Regarding the speeds of the separate elements of the meter, I would say that from the information submitted it appears that the two phases are unbalanced with respect to either load or power factor or both. This is apparent from the two voltages noted and if current and power factor values were known, the exact amount of unbalance could be calculated and it would be found that the meter element connected to the phase having the highest load in kilowatts would naturally be the faster.

This explanation is based on the assumption that both the current and potential transformers are of the same size and have similar characteristics and that the two meter elements are not defective and are properly adjusted for accuracy and balance. It is also assumed that the double throw switch is making good contacts.

If, after making tests, it is found that there is a material difference between the loads on the two phases, steps should be taken to equalize the load as closely as possible so that better voltage conditions would prevail and machine operation and service would in general be improved.

C. F. MATHES.

Summit, N. J.

Centrifugal Tension in Belts

WITH FURTHER reference to the matter of centrifugal tension in belts which has been recently discussed in Power Plant Engineering, the writer is in receipt of an interesting report of a test to determine the effect of speed and tension on the transmitting capacity of leather belting by R. F. Jones, Research Engineer of the Leather Belting Exchange. Although this matter has not yet been printed in any publication, I have been given permission by Louis W. Arny, Secretary of the Exchange, to make quotations from the report.

"There are two factors to be examined which directly affect the horsepower a belt will transmit; the first is the effective pull or working tension which the belt can exert, and the second is the speed at which the belt is running. If these two are multiplied together and divided by 33,000, the result is horsepower; therefore, if the effective pull or tension remains the same at all speeds, the horsepower will be increased in the same proportion as the speed is increased. Now at the higher speeds the centrifugal force or tendency to pull away from the pulley is very much increased, so that the force with which the belt clings to the pulley is reduced. This in turn reduces the effective pull of the belt, so that while an increase in speed would increase the horsepower due to the faster rate of doing the work, the reduction in effective pull or tension, due to the centrifugal force at the higher speed causes the rate of horsepower increase to drop off. This is especially noticed at 5000 ft. per min., where there is a comparatively small increase in horsepower as a result of the increase in speed. At the higher tensions, the effect is not so marked, because the centrifugal force does not decrease the effective pull as much at these tensions.

"Centrifugal force increases as the square of the velocity. At 1010 ft. per min., the computed centrifugal force on the test belt is 5.8 lb.; at 2020 ft. per min., it is 23.4 lb.; at 3030, it is 53 lb.; at 4040 it is 95 lb. and at 5050 it is 147 lb. It becomes 376 lb. at 8000 ft. per min., so that at this speed no power could be transmitted unless the initial or slow running tension was greater than 376 lb. Since the centrifugal force at 5050 ft. per min. is 147 lb., the belt's hold on the pulley must have been greatly reduced at the lowest slow running tension of 197 lb.

"Our machine measures only the tension being applied to the pulleys and not the total in the belt, a part of which is due to centrifugal force. At the higher speeds centrifugal force is greater and therefore the measured tension is less. As the load is increased, however, most of the working tension is transferred to the bottom or tight side of the belt, while the loose side becomes slack. Thus, regardless of the speed or slow running tension, the effective tension gradually approaches the total tension in value.

"In general, under practical ratings, the tension on the bearings is increased by an increase of slow-running tension and decreased by an increase of speed."

This quotation supports the writer's argument on this subject. Further quotations from the report are interesting and further substantiate the writer's arguments on centrifugal tension that have been published from time to time in Power Plant Engineering.

"At each tension the arc of contact increases with the speed instead of decreasing as is commonly thought. The general supposition has been that the greater centrifugal force of the belt around the pulley caused the sag to decrease as the speed is increased. It seems that instead the top side of the belt forms a curve which is also acted upon by centrifugal force, so that as the speed is increased there is more and more force tending to hold the top side slack. This is because the tension in the loose side is great enough to overcome the effect of centrifugal force. At greater loads the top side became slack and then speed has its effect of increasing the arc of contact.

"Again we find that at the higher tension speed does not increase the arc nearly as much as it does at the lower tensions.

"Our broad conclusion is that the arc of contact increases with the speed and decreases with the slow running or initial tension."

Newark, N. J. W. F. SCHAPHORST.

Method of Heating Gas Tank Seal Water

REFERRING TO an article on heating gas tank seal water which appeared on page 197 of the Feb. 1 issue, it is stated that steam coils are commonly used for this purpose. The most practical and what I believe to be the most generally used method is to heat this water by means of steam ejectors. They are highly efficient, and have the advantage, if properly arranged, of keeping the water in motion.

Plainfield, N. J. THOS. L. MELLICK.

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Storing Coal Will Aid Industry

That industry in general throughout the country has suffered great losses due to the unhealthy conditions that exist in the coal mining industry cannot be doubted. The industries and public utilities of the country combined use 32 per cent of the entire output of the coal mines and being so dependent upon the fuel supply for their operation are watching with interest the work and recommendations of the Federal Fuel Commission that is investigating the conditions in the coal industry.

Undoubtedly the practices of some of the principal coal users in purchasing coal have an influence on stability of the market and the continuity of production which should be brought to bear to the fullest extent for the betterment of the fuel situation. If, for example, the industrial establishments, public utilities and the railroads, which combined use 60 per cent of the coal production, could purchase coal as a unit, they could control the market so as to cause a uniform, continuous demand which would call for continuous mine operation.

Among the principal causes of decreased production in many mines today is the lack of cars for transportation. Some of this is due to long rail hauls which in many cases might be reduced by the use of waterways, particularly in the shipment of eastern coals to the northwest section of the country. Another remedy offered is the storage of coal at the point of use during the period of the year when cars are not being used for grain transportation and storage at the mines during the grain-carrying season.

Too many mines and miners seem to be the causes most commonly blamed for the present unhealthy condition of the industry. A suggested remedy for these conditions is continuous production on a competitive 24-hr. basis, thus weeding out the inefficient mines and unemployed miners.

Power plants of all classes that use coal as fuel can aid in the effort to correct bad conditions in the coal industry, and at the same time insure a fuel supply for themselves, by storing sufficient coal during the summer months to see them through the car shortage period of the fall and early winter. In order to encourage such a practice it has been suggested that a reduction in coal prices and freight rates during the proper periods of the year be offered as inducements to fuel users.

So closely is the network of industry interwoven that a break in one thread will affect the entire fabric. If each industry does its share towards the mending, the burden on all will be lighter.

Annual Report Offers Opportunities to Engineers

At the end of the calendar, or the fiscal year of the company, the most successful engineers work out what they term their "Annual Reports" covering the operation of their plants, and more men operating and getting results from power plants should take advantage of this opportunity of bringing their work before the attention of the "powers that be".

Too frequently the complaint of the small plant engineer is that his work is not appreciated and is overlooked by the heads of the concern, and usually it is the case, because the operating man fails to "advertise" his work, his accomplishments, and the difficulties he has overcome or has to overcome to the man higher up.

It will be found that other department heads in the plant lay their accomplishments and their recommendations for changes before the manager in formal fashion—why should not the head of the power producing department follow the same course in pointing out the accomplishments of the year, the handicaps which have been met and overcome, the records which have been made in the way of costs or reduced expense, and recommendations as to new equipment which should be purchased or old equipment which should be replaced?

Getting together such a report has a far-reaching effect, for it not only causes the engineer to pay special attention to his operating conditions and records so that an intelligent summary and survey can be submitted, but it also gives him the opportunity of submitting ideas, suggestions and recommendations at a time and in a form which the management likes to have them; hence conditions are more favorable for full consideration and adoption.

Such a presentation is also important from the engineers' standpoint, for once the owner's attention is directed to the full responsbility and importance of the engineers' duties the better is the chance for securing proper services rendered. It is surprising how such a report will result in increased respect and confidence on the part of the people in charge, and how it will in time bring an engineer and his work out of the obscurity of the power plant into the status of one of the real departmental heads of the business. It is, therefore, advisable for every operating engineer to make an annual report which will explain the work done and to be done.

Off Duty

FORMULA: "A bit of blown glass, a small quantity of metal, some pieces of wood or other fibrous material, an ounce or two of cotton or silk, and a few simple chemical compounds." Fashion the foregoing ingredients into suitable shapes, put them together in correct juxtaposition, and you have at your command an apparatus which practically annihilates distance insofar as transfer of human intelligence is concerned.

There is nothing strange nor rare that enters into the construction of modern radio equipment, and in many cases the construction itself is characterized by a remarkable degree of simplicity. It is true that certain synthetic products are made use of in practice; but these, in many cases, could be replaced by wood without materially affecting the action of the instruments. All of the above named substances have been available for centuries. The use of woods and metals dates back to the dawn of civilization, cloth fabric has always formed part of human wearing apparel, glass was used by the Egyptians over 4000 yr. ago. Had the Greek mathematicians and philosophers or the alchemists of the middle ages but known how, they could have constructed a radio apparatus without any great difficulty, for all the material included in its construction was at hand.

But that's just where those old fellows fell down—they didn't know how. This, however, is not to be held against them, for although the necessary material was at hand, there was something very important lacking. That something was the knowledge of the underlying principles upon which the art of radio communication in general is founded.

Some of the modern instruments used in the art of communication, particularly in the field of radio, are extremely simple, but hidden in their simplicity lies untold years of research and mental effort. Crude and simple as it was, it was a long cry from Alexander Bell's vibrating clockspring which marked the birth of the telephone back to the beacon fires of historic times, but not nearly so far as it is from Bell's first telephone to the radio telephone of today. The time interval separating the latter two events is far less than that separating the former two, but when considered from the point of view of mental energy expended, there is no comparing the two intervals—the latter by far eclipses the former.

Progress in any field of endeavor is directly dependent upon our knowledge of fundamentals. Today, the art of communication is advancing by leaps and bounds—new, amazing feats are accomplished every day and even the men engaged in the work of developing the art have difficulty in keeping abreast of the subject. Why is this? Is it because of the fact that so many people are interested in and think about the same subject? While, on first thought, one may be inclined to attribute the rapid progress to this fact, it is not the case.

It is true, thousands of people are interested in radio today and its effect upon the development of the art is not to be ignored, yet practically all of the great achievements in telegraphy, telephony and radio, have come from a relatively small group of men whose sole efforts have been expended in perfecting the art. The work of these scientists is based upon the accumulative results of years of research and thought in a dozen branches of science. They are in possession of fundamental laws which underlie the art and as their knowledge of these laws multiplies, so will the results of their efforts multiply.

Twenty four years ago this month, Marconi sent the first radio message across the English Channel. A little over a month ago, H. B. Thayer, President of the American Telephone and Telegraph Co., sat in his office in New York on a Sunday night with an ordinary telephone instrument in front of him, and, in an ordinary tone of voice, addressed a group of men, among who was Mr. Marconi, at New Southgate, a suburb of London. In the office where he sat, there was no indication that anything unusual was happening—the silence of the room was broken only by the measured tones of his voice. Outside, however, for hundreds of thousands of square miles the ether reverberated with the vibrations of his hundred kilowatt voice, and, eleven minutes later, there came a cablegram from England, three thousand miles away, saying that all had been heard and understood.

So much for the present. The time is not far distant when we will be able to go to our telephone, give central the name of a person in London, or in Bombay, or in Buenos Aires and within the course of a few minutes, converse with that person as easily as we do now with a person across the city in which we live.

"This," in the words of John Carty of the American Telephone and Telegraph Co., "is the Golden age of communication. Already it has achieved the extension of the spoken word throughout both space and time; but it is not yet ended. When we contemplate the possibilities of the future, we discover that it has only just begun. It is to the future that we must now turn our minds and direct our endeavors."

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Use of Turbine Feed Pumps Affects Governor Design

SINCE the advent of turbine driven boiler feed pumps the problem of securing satisfactory governor operation has occupied the attention of engineers, both in the designing and operating fields, although efforts

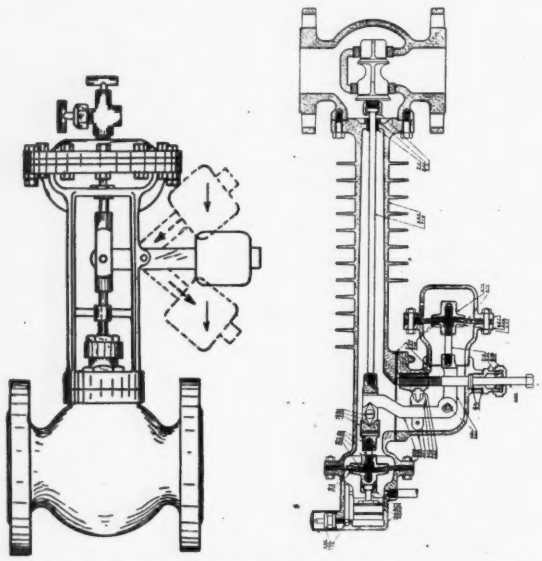


FIG. 1. DOTTED LINES SHOW HOW FORCE COMPONENTS CHANGE IN THE WEIGHT AND LEVER TYPE OF PUMP GOVERNOR

FIG 2. PUMP GOVERNOR IS DIAPHRAGM OPERATED WITHOUT USE OF SPRINGS OR WEIGHTS

along this line have been directed mainly to an attempt to adapt the existing types of governors to such use rather than any departure from accepted practice. With the rapidly increasing pressures met with in modern power plant design the defects of the earlier designs have been brought out quite forcibly.

In the majority of previous designs, springs or weights are used to counterbalance the excess pressure and although the building up action of a weight or spring is not so noticeable at low pressures, the tendency to oscillate is always noticeable and with higher pressures the use of such governors is rendered almost impractical. A governor valve disc must necessarily change its position with relation to the seats for any change in demand, or steam pressure, and this cannot occur without an increase or decrease of spring tension with a corresponding change in pressure. The action of a weight as applied to governors is illustrated in Fig. 1. With the valve in mid position, lever horizontal and weight in mid travel, maximum force is exerted, but as valve travels either towards the closed or open position a portion of the force due to the weight is transmitted longitudinally through the lever as shown by the dotted arrows. A study of this sketch will make it apparent that the net force due to the weight operating the valve is not constant, but changes with each change in valve position and therefore the pressure will vary with it.

With these facts in mind an investigation was begun in 1922 by the S. C. Regulator Co. to determine what could be done to meet this condition and an analysis of the problem showed that the following points must be covered to obtain proper regulation:

1. Excess pressure in the feed line must at all times be held at a constant pressure over the steam pressure regardless of demand on the pumps.
2. There must be no surging or hunting of the governor, as this would cause pounding or water hammer in the feed lines and terrific strains on the pump.
3. Due to the extreme sensitiveness of the turbine and quick response to changes of steam pressure at the throttle the governor must respond instantly to very small changes in pressure and do this smoothly and gradually and without hunting.
4. To maintain a constant excess pressure under all demands the governor valve must be able to assume any position relative to the seats that the demand may call for and this without appreciable change in pressure.
5. Simplicity of design is needed with a minimum of wearing parts, in order to insure continuity of service.
6. Strength and ruggedness of construction are important because of the high pressures to be met.

Referring now to Fig. 2, it will be seen how a governor was worked out in order to meet these conditions. The valve is installed so that working mechanism hangs in a vertical line below the valve body, the casing having been filled with water to protect diaphragms from contact with steam when starting governor for first time. After governor is in service condensation of steam in upper portion keeps water level at third radiator ring from valve body with a temperature around the disc of 600 deg. F. Steam enters the case through the bushing around the valve stem, which is a very loose fit and also serves as a limit stop to prevent the disc from traveling too far in the open position.

Main valve stem passes through the diaphragm at bottom of the chamber and a dashpot piston is attached to end of stem. This dashpot serves to stabilize the action of governor and prevent hunting; regulation of dashpot action is obtained by providing a bypass around piston, this bypass being controlled by a needle valve manually operated. When once set for working conditions no further attention is required.

Feed line pressure is admitted to the under side of the bottom diaphragm through pipe shown. The upper diaphragm has a stem passing through it with suitable plates to make a leak tight joint (upper surface of this diaphragm is exposed to atmosphere through a vent provided in the cap) and this stem is linked to the main valve stem through the yoke and lever shown. The combined action of steam pressure transmitted through the water to the diaphragms tends to open the valve. The action of water pressure under the bottom diaphragm tends to close the valve. The area of upper diaphragm is so calculated as just to balance the excess pressure desired, when the fulcrum on lever is in mid position. This fulcrum is adjustable by screw as shown and gives 20 per cent range of excess pressure up or down.

Maximum travel of the diaphragms is such that valve disc movement of only 1 inch is obtained which in most cases is double the travel necessary and therefore no resistance can be set up at this point. Since all bearings are knife edge and there is no stuffing-box on the valve stem, friction has been eliminated.

It is apparent then that valve disc is free to move through its entire travel without any change in resistance and, therefore, will assume the proper opening position for any demand on the pump to control the pressure within a few ounces of that for which it is set.

It should be borne in mind that the diaphragms are always covered with cool water, are specially built up to withstand the pressure and no trouble has been experienced in their operation. It will also be noticed that valve stems pass through the center of the diaphragms which have heavy plates on each side held with lock nuts which add to the strength of the diaphragms. At the same time the areas of these plates are so proportioned to the area of diaphragms as properly to distribute the bending action over a sufficiently large area to give long life.

Synchronous Timer for Testing Relays

TO MEET the demand for an accurate method of timing relay operations, the General Electric Co. has recently developed a synchronous timer known as the Type MF-1. The value of relays when used in conjunction with other protective apparatus is often dependent upon the accurate measurement of time intervals, and the timing of the relay operation.

This new synchronous timer operates on 50 or 60 cycles, 110-v. supply, with a permissible voltage variation of 10 per cent. A synchronous motor operates the clock hands through a gear train, a friction clutch enabling the hands to be started and stopped with the motor running at synchronous speed. This starting and stopping occurs within a fraction of a cycle, so that the resultant error is not appreciable. A solenoid operated plunger normally engages a ratchet wheel and prevents rotation of the clock hands by causing the clutch to slip. When the solenoid is energized, the plunger releases the ratchet, allowing the clutch to hold. The ratchet will permit the hands to be turned back to the stop by means of the reset knob, but will not allow them to be turned forward. The solenoid, with its series resistor, is designed for use on a 110-v. alternating or direct current circuit, and the hands may be stopped either by short-circuiting the solenoid (clutch) and leaving the resistor across the line, or by opening the solenoid circuit.

The dial has a standard clock face with standard ratio clock hands, the large hand making one revolution

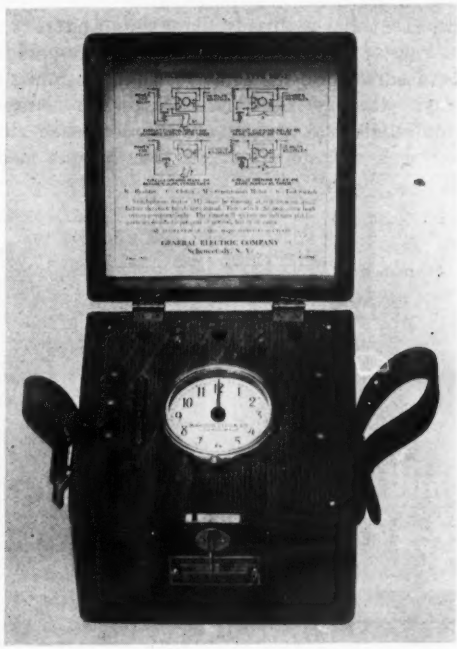


FIG. 1. TYPE MF-1 SYNCHRONOUS TIMER

for every 60 cycles of time, while the small hand moves five small divisions, or one-twelfth of a revolution, in the same time. Obviously the indicated time in seconds is dependent upon the synchronous motor supply frequence, but in all cases one revolution of the large hand indicates 60 cycles.

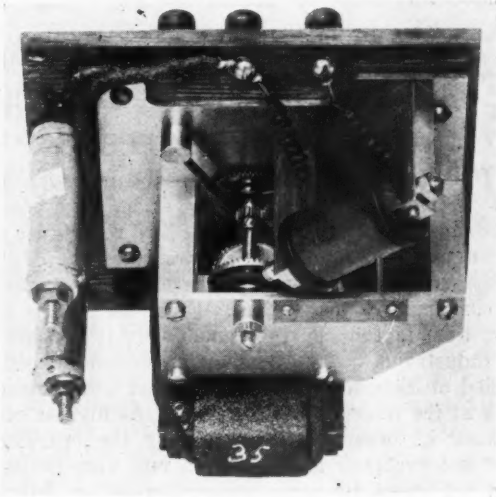


FIG. 2. MECHANISM OF TIMER

If the readings are put down in clock time (as 2:20 for two revolutions, 20 cycles, equivalent to 2 sec. and 20 cycles on a 60-cycle system) and later converted into seconds or cycles, they can be taken very rapidly and accurately.

It is not necessary to disconnect the timer from the circuit while adjusting the current through the relay, as the timer can be quickly reset to the starting position after the current is adjusted and before the reading is to be taken. The relay may be connected to a source separate from the timer when making tests on different frequencies, direct current, and current or low voltage relays. In such a case a double-pole switch must be used to close the timer and relay circuits simultaneously. It may also be necessary to connect the timer and the relay to separate sources when checking

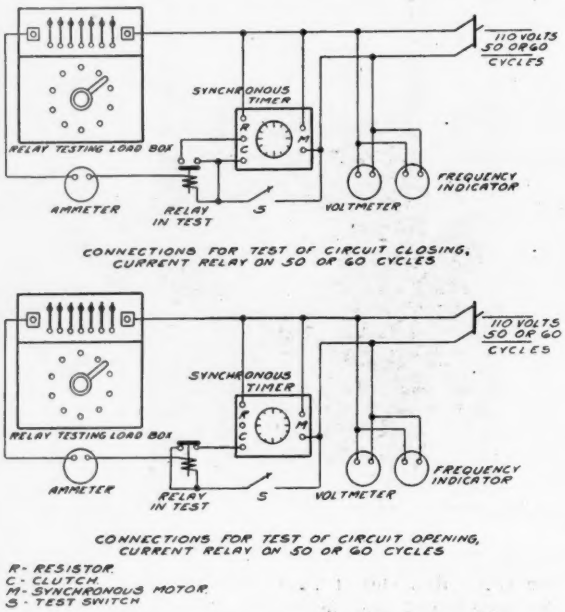


FIG. 3. SHOWING METHOD OF CONNECTING TIMER

relay operations where the current used in checking is sufficiently heavy to reduce the line voltage below that necessary to operate the timer.

Coal Commission Is Making Definite Progress

WHILE THE WORK of the coal commission is not yet completed and the data which have been collected must be correlated before the final reports are made to congress, nevertheless the work has proceeded far enough so that the causes of the chaotic conditions in the coal industry are evident. From the reports issued from time to time by the commission, it appears that the industry is badly organized, is over-developed, the method of distribution is not perfected and engineering work at the mines is not always of the highest calibre.

Lack of organized means among the operators to meet the problems of production and distribution has been set down by some authorities as an important factor in bringing on present conditions. The workers are fairly well organized and in a position to make proposals regarding labor and other conditions which the operators are unable to meet in a definite way because of the lack of unanimity.

Even more important, however, is the over-development of the industry. There is little question but that the commission is of the opinion that there are too many mines and too many miners. In the bituminous field there are 9000 mines operated by 6000 companies, in 29 states. There are about 750,000 bituminous miners, which is said to be 200,000 more than needed to operate the mines on a fairly constant output basis. With this reduced number of miners and with the present mines, production of coal should be 800,000,000 T. annually as compared with a maximum consumption for the country of 500,000,000 T.

Another phase of this over-development is the number of middle men. It has been estimated that there are 90,000 distributors in between the mines and the ultimate consumers. It is thought that at least half of these could be gotton rid of with good effect to the industry.

In the anthracite fields, the situation is not quite the same, as fully 93 per cent of this coal comes from a small eastern district of about 453 sq. mi. The importance of the anthracite production, to the country at large, is not of such magnitude as that of bituminous. For instance, the capital investment in the former is $2,000,000,000, while for anthracite the investment is probably near $500,000,000.

One big problem which must be solved, according to views which have been expressed by several members of the commission, is that of placing the industry on a constant basis of production. Several methods have been proposed, one of which is a lowering of the freight rate during the summer months, as well as a reduction in price of coal, both of which would tend to stimulate the storing of coal by users, particularly the industries.

This would tend to spread out production and eliminate the pressure on transportation. It so happens that the peak of the coal movement coincides with the moving of wheat crops and consequently the burden on the railroads is unusually heavy. In fact, during the past few months transportation has been fully as important as coal production.

Distribution figures on coal show that the railroads use 28 per cent; industries, 25 per cent; coking purposes, 15 per cent; domestic consumption, 10 per cent; public utilities, 7 per cent, and export, 2 per cent, of the total coal produced. As the railroads are the largest users, it is proposed in some quarters that they should be required to store coal at division points to a total of at least 10 per cent of their needs. This would tend to relieve conditions at the time of peak consumption. At the present time railroads are the first to take advantage of priorities and to commandeer coal when necessity arises.

Pooling of coal cars is another suggestion which may be urged on the railroads. According to present methods one line makes a shipment of coal possibly several hundred miles and the cars are sent back empty, when in all probability the cars could be used to good advantage on the return trip.

Another point which may be brought to the attention of the Inter-State Commerce Commission is the setting of differential rates which will tend to encourage hauls by water. For example, the present rate for a 150 mi. haul from the Pennsylvania fields to the nearest lake port plus the water haul from Duluth of 40 cents a ton plus the 300 mi. haul to St. Paul is con-

siderably more than the rate from the Illinois fields some 600 mi. away. In other words, the total rail haul by the lake route is 450 mi. as against 600 mi. from the Illinois field. As the first 150 mi. rate from the Pennsylvania field to the port on the lake is $1.74 per ton, it can be seen that the present rate favors the Illinois fields.

As a result of such rates the central states territory during the past winter has been drained of coal for shipment to the northwest, when in reality Pennsylvania coal should have gone into that territory. If the coal had gone by the lakes route the required rail haul would have been a short one on both ends and cars could have been conserved in the Illinois fields.

Frequently it is necessary for the mines to shut down for a few hours while awaiting the receipt of cars. The commission has, therefore, been considering the advisability of the mines using emergency bins to hold the supply until the arrival of the cars. This has already been worked out in a number of cases, it is reported.

One mining engineer of prominence has asserted that the engineering work in the coal industry has not been of the highest type. In the viewpoint of this expert there are too many rules of thumb men handling engineering problems in coal mining. This same man pointed to the metal mines of the country as to what might be accomplished by higher caliber engineering. In the opinion of this engineer the single 8-hr. shift for a mine is extremely uneconomical. In order to reduce the overhead charges per ton, a mine should operate at least 16 hr. and preferably 24 hr. a day as they do in iron and copper mining.

In this connection, of course, the fundamental difficulty is the over-development of the industry previously cited.

There has also been a big waste in getting out coal, although the condition is somewhat improved. About 15 yr. ago the average mine tooled out about 50 per cent of the coal, whereas today most mines get out from 75 to 80 per cent. In the opinion of some mining men this figure should be from 80 to 90 per cent if the most is to be made of our coal resources.

While it appears to be the intention of the commission to steer clear of suggesting government operation of the mines, it is quite possible that some scheme of Federal supervision of both labor and operators may be suggested.

According to the act of Congress which created the coal commission, the work will finish in September. There is a movement on foot, however, among certain members of Congress, to make the commission a permanent body, although the outcome of this is still indefinite.

New Oil Circuit Breakers for Industrial Use

TYPE F-10 denotes a new line of oil circuit breakers which the Westinghouse Electric and Manufacturing Co. has recently placed on the market for use in mines, textile, cement and flour mills.

The new breakers are of moderate interrupting ability and are made in capacities up to 200 amp. at 2500 v. and 800 amp. at 750 v. They are wall-mounting breakers, designed for indoor service only. As they are dust-proof and drip-proof, they are well suited for use in the industries mentioned above.

All type F-10 breakers are manually-operated and may be either non-automatic or automatic. The breaker is held in the closed position by a hardened steel roller, which is tied on the trigger so that when the trip coil is energized the trigger is raised, disengaging the latch and allowing the breaker to open. When the breaker is used non-automatic, it is tripped by raising the closing handle. When the breaker is in position, the operating handle is vertical and when the breaker is opened the handle is raised slightly. It is thereby possible to

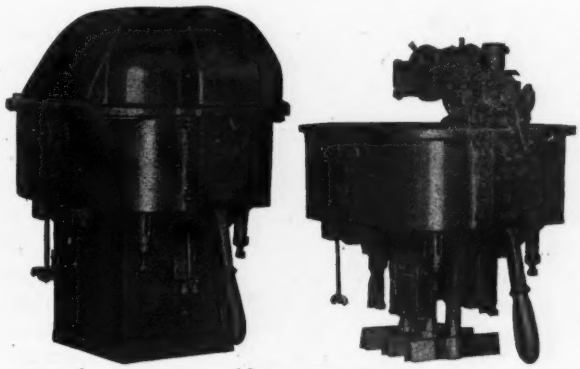


FIG. 1. NEW TYPE F-10 OIL CIRCUIT BREAKER, CLOSED
FIG. 2. TYPE F-10 OIL CIRCUIT BREAKER, OPEN

determine the position of the contacts by the position of the handle.

Automatic operation is obtained by the addition of one or more automatic trip attachments.

Hetch Hetchy Power House Work Is Begun

CONSTRUCTION of the hydroelectric power house that the city of San Francisco is building at Moccasin Creek as an auxiliary to the Hetch Hetchy water supply project, is well under way and will be completed in about a year, it was announced a few days ago by City Engineer M. M. O'Shaughnessy. Contracts for the entire project have now been let and proceedings have been undertaken to acquire right of way and equipment for the transmission line into San Francisco.

The power house and its equipment will cost approximately $5,000,000. At the start, four units only will be installed in the power house, each one capable of generating 17,500 kw. of electric energy.

When completed the power house will be 300 ft. in length and almost 100 ft. in width. It is located in a beautiful spot in the Sierra at the foot of high hills down which the water from the Hetch Hetchy system will plunge through the penstock pipes leading out of the Priest reservoir at the end of the mountain division of the tunnels.

Water for operating the plant, after being impounded at the Hetch Hetchy dam, now practically completed, will be carried through 18 mi. of 10 ft. 3-in. tunnels bored through the solid granite, to the Priest reservoir on the hill above the power house. Leaving the power house the water will pass on its way through tun-

nel and pipe line to the bay region, as that feature of the project is undertaken.

Construction of the Priest dam at the lower end of the 18-mi. tunnel aqueduct is proceeding satisfactorily, O'Shaughnessy reports.

This dam which is a $1,000,000 structure, as compared with $5,000,000 for the Hetch Hetchy dam, will create a regulating reservoir to control the flow of water from the tunnel aqueduct before it is dropped down the mountain side through penstock pipes into the Moccasin Creek power house. The Priest dam is about half complete. It will be 100 ft. long at the crest and have a maximum height of 145 ft. and will create a reservoir of 2500 acre ft. of water.

It is being constructed with a concrete core wall on each side of which is an earthen fill. The upstream fill is being built by hydraulic means.

New Weighing Meter Operates With Dumping Bucket

FOR weighing comparatively small quantities of water, where a V-notch meter would be unsuitable, a dumping bucket type of meter has recently been developed. The use of the meter is not, however, restricted to the smaller capacities as the principle of operation is applicable to higher rates of flow. This weighing meter actually weighs the liquid by balancing a bucket

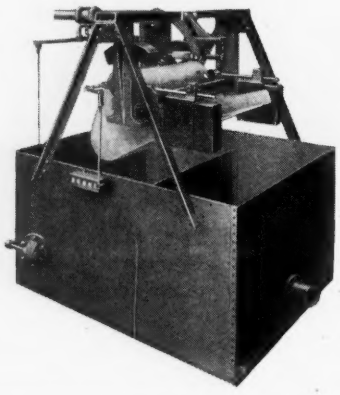


FIG. 1. BUCKET IS BALANCED AGAINST A SCALE BEAM AND NUMBER OF DUMPINGS IS RECORDED

against a balance weight on a scale beam. The bucket rests upon the beam by frictionless trunnions, while the beam is supported on knife-edge bearings. When a certain weight of water has accumulated in the bucket the latter sinks until it escapes a latch and then turns over and discharges its contents.

During the time that the bucket is rotating, the inflowing water is received in a detaining chamber. As soon as the bucket has discharged, it swings back so that the liquid in the detaining chamber flows into the main bucket, which thereupon proceeds to revolve slowly to its initial position. In so doing, it travels a short distance past the latch and then, as more water flows in, slowly comes back against the latch, engaging and locking with the latter, the balance weight having already already returned the bucket to its original elevation. This may be seen in Fig. 2 showing six successive positions of the bucket.

Each dumping is registered by a counting train and the accuracy is within one per cent, plus or minus, at all rates of flow up to the maximum. The meter is calibrated by weighing a single discharge and can be adjusted by moving one or both of the counterweights. The receiving tank into which the meter discharges can be fitted with a float controlling a valve in the inlet

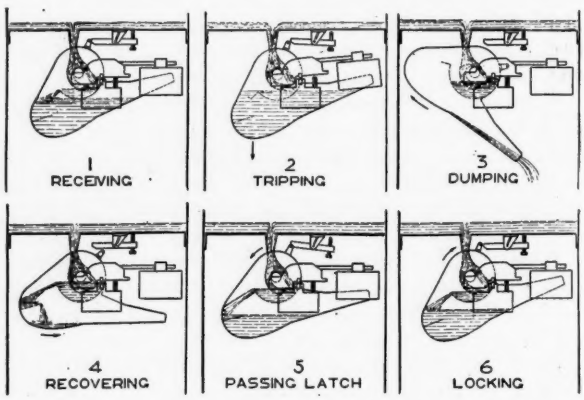


FIG. 2. SIX CONSECUTIVE POSITIONS OF THE BUCKET IN THE FILLING AND DUMPING CYCLE

connections, where the amount is controlled by the apparatus to which the liquid flows rather than by the apparatus from which it comes. Meters of this type are built by the H. S. B. W.-Cochrane Corporation, of Philadelphia.

Detroit Edison Co. to Extend Its Distribution System

IN ORDER to take care of its rapidly increasing load, the Detroit Edison Co. proposes to establish a 120,000-v. transmission system around the territory in which it serves power. It is intended to tie the new 120,000-v. ring into the present 24,000-v. system at several points. The power at one of the existing power stations will be transformed from 12,000 v. to 120,000 v. through a bank of three 12,000-kv.a. single phase transformers. The power will be transmitted at 120,000 v. for a distance of approximately 60 mi. and it will then be stepped down to 24,000 v. and tied in with the 24,000-v. system through a bank of three 5000-kv.a., oil insulated, water cooled, single phase, 60-cycle transformers.

At an intermediate point, the 120,000-v. line will be tied to the 24,000-v. system through a bank of three 5000-kv.a. oil insulated, self cooled, single phase, 60-cycle transformers, delta connected on the high tension side and star connected on the low tension side. Self cooled transformers are being used at this point because of the very limited water supply. With the connections provided in the three banks of transformers both the 120,000-v. system and the 24,000-v. system can be grounded, and the 120,000-v. line will be operated with the neutral connected solidly to the ground. The transformers and other apparatus will be furnished by the Westinghouse Electric & Manufacturing Co.

English Firm Puts Out Novel Voltage Regulator

AN INGENIOUS and simple voltage regulator suitable for use in connection with small direct-current electric generators—up to a capacity of 50 kw.—is illustrated in the accompanying figures. The device which is described in Engineering of London is being manufactured by Messrs. Isenthal and Co., Limited, Willesden, N. W. 10, is likely to be particularly useful for application to dynamos driven by oil or gas engines, the speed of which is subject to considerable fluctuations. Small machines supplying circuits containing motors may in many cases also profitably be fitted, as in such cases the voltage is liable to fall considerably when a motor is being started-up. The regulator also permits of the driving of dynamos by engines fitted with only primitive governors which would normally be unsuitable for electricity supply.

This device utilizes the principle of intermittent contact which is used in the Tirrill regulator. There is a pair of vibrating contacts which periodically short-circuit and open the field resistance of the dynamo, while a solenoid, which operates in response to the dynamo voltage, determines the relative positions of these contacts and consequently the period of short-circuit. This introduces a short-circuit time factor as a function of the supplied voltage and results in such regulation of the field that that voltage is kept constant.

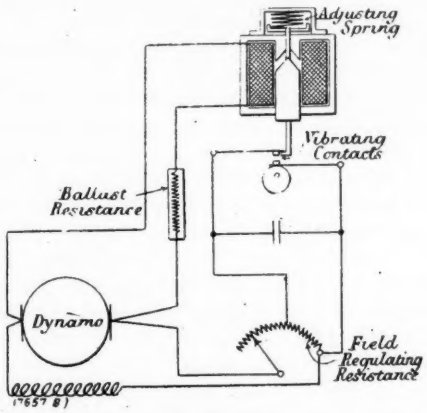


FIG. 1. SCHEME OF CONNECTIONS OF NEW REGULATOR

The arrangement is mechanically and electrically a simple one, and will be followed from the figures. The various items concerned are shown in a diagrammatic way in Fig. 1. The vibrating contacts which are connected across the field resistance are carried by flat steel springs. The spring of the lower contact rests on an eccentric which is keyed to the dynamo shaft, so that as the dynamo rotates the contact is rapidly vibrated and constantly makes and breaks connection with the upper contact. This upper contact is attached to the plunger of a solenoid, the winding of which is connected across the machine, so that the position of the plunger and consequently of the upper contact varies according to voltage. Alteration in position of the contact alters the period of short-circuit. A helical spring is fixed above the plunger which enables the appliance to be adjusted and a condenser is connected across the short-circuiting contacts to prevent sparking.

The general appearance of the regulator is well shown in Fig. 2. It is mounted in a cast-iron casing which is carried either from the machine frame, or on a cast-iron pedestal. It is mounted at the end of the machine shaft in order to get the necessary eccentric drive in a simple way, but a more indirect drive could

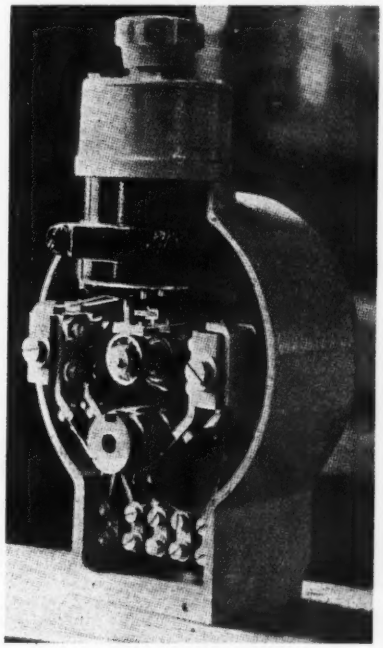


FIG. 2 THIS REGULATOR IS MOUNTED AT THE END OF THE GENERATOR SHAFT

no doubt be worked out if in any particular case this proved necessary. A double-throw switch is mounted on the regulator case, which enables the polarity of the vibrating contacts to be reversed. This considerably prolongs their life. The apparatus is suitable for use on machines up to a voltage of 500 and up to a maximum field current of 5 amp. It may finally be noted that the regulator automatically controls the voltage of the dynamo during starting and will bring it to the normal working condition without the field rheostat being touched.

New Diesel Engine Association Plans Educational Campaign

PROMOTION OF the use of Diesel engines as a type of prime mover suitable for both marine and stationary service will be an important part of the activities of the recently organized Diesel Engine Manufacturers' Association. In carrying out such work, however, the members of the association will attempt to show the merits of the Diesel engine by presentation of definite facts regarding possible applications.

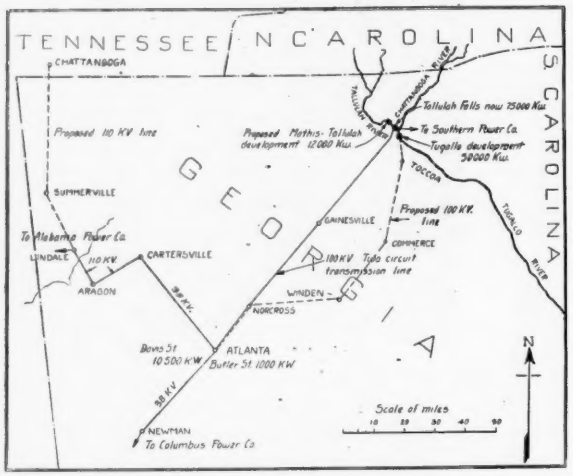
According to F. W. Gay of the De La Vergne Machine Co., who is chairman of the membership committee, the members realize that other types of prime movers have a definite field of application, but they do believe that the possibilities of the Diesel engine should be presented

in the strongest manner. Besides the promotion of interest in Diesel engines, the association also has as its object the development of business standards and ethics among its members.

This association was organized early in 1922 with A. F. Bowen of the New London Ship & Engine Co. as president; Fred Nolde of the De La Vergne Machine Co., secretary, and Mr. Gay as chairman of the membership committee. It is expected that the association will meet early this year, at which time plans for carrying out the work will be outlined and new officers elected.

Further Power Development in Southern States

APPROXIMATELY $6,500,000 will be expended by the Georgia Railway and Power Co. under its 1923 program of development and improvement, this outlay providing for enlarged and improved car, electric and



GEORGIA RAILWAY AND POWER COMPANY TO EXTEND PLANT AND TRANSMISSION FACILITIES

gas service in the immediate Atlantic territory; the construction of a new hydroelectric station at Tallulah Falls; the erection the additional transmission lines throughout north Georgia, and various other important features.

In Atlanta both the Butler St. and Davis St. steam plants will be enlarged and improved. There will be an entirely new substation near the Walton St. substation, but the exact location of this new structure has not yet been determined. A new 19,000-v. line will be built from the Boulevard substation to Randolph St. and Auburn Ave. to feed the underground system, and Decatur and the entire underground system will be enlarged and improved.

Erection of the Mathis-Tallulah power plant, at a cost of approximately $1,000,000, is the largest single item on the program. The development provides for a new power house at the head of the Tallulah lake, which will be started in 1923 and finished in the fall of 1924, or sooner.

This development also calls for a tunnel which will be driven for a mile through the mountain side, starting at the Lakemont or Mathis dam. This tunnel will feed water into the new power house to be built at the head of the Tallaluh lake. This power house will have a head of 190 ft. and a capacity of 22,000 hp., with an output of 63,000,000 kw.-hr. annually. According to plans the new power house will be of the automatic, remote control type and will be operated from the Tallulah plant, it being unnecessary to station anyone at the new plant. The entire flow of the river will feed through the tunnel into the new power house, out into the Tallulah lake, thence through water wheels of the Tallulah power house, on to Tugalo, where the water will be used over again a third time.

To Complete Tugalo

WHILE THE Mathis-Tallulah development is under construction, the Tugalo development, resumed Jan. 1, 1922, will be completed. The Tugalo power house, erected at a dam being constructed where the Tallulah and Chattanooga Rivers join in forming the Tugalo, will be in operation in the fall of 1923. The output from its 88,000 hp. capacity will increase the hydroelectric output of the company approximately 50 per cent. The Mathis-Tallulah power plant will have an output 45 per cent of that of Tugalo, due to the fact that it will operate practically continually.

Re-building of the Morgan Falls or Bull Sluice power plant, 20 miles from Atlanta, will be completed in 1923, increasing the capacity of this water power plant 50 per cent. Work on this plant, already approximately half completed, will be continued and finished by the time the Mathis-Tallulah and the Tugalo developments are completed, meaning that three power plants will be under construction simultaneously.

Already leading from Tallulah to Atlanta by way of Gainesville and Norcross is a 110,000-v. high-tension line, carrying two circuits. In addition to this the 1923 program calls for a third high-tension line from Tallulah to Toccoa to Commerce to Winder to Norcross to Atlanta. This line, without the transformer stations that will accompany it, will cost about $735,000.

Power from Tugalo, the Mathis-Tallulah power house and the Tallulah plant, will be controlled at a switching station at Tallulah, making it possible for all transmission lines to have a dependable and continuous service, since the power from any plant can be switched onto any line whenever desired.

Thus, through the new substations, power house and transmission lines and the new switching station at Tallulah, all towns served by the company will have a constant, dependable and tremendous source of power always available. In addition, the entire Georgia Railway and Power Co. system will be backed by adequate steam plants and by the facilities of the power companies of Alabama, Tennessee and the Carolinas, which can be drawn upon through connections of high-tension lines of Georgia and the four other states.

Spring Meeting of A. I. E. E. to be at Pittsburgh

THE SPRING meeting of the American Institute of Electrical Engineers will be held in Pittsburgh, April 24-26. Many central station and industrial problems will be discussed at this meeting and a number of interesting inspection trips are planned. Included among

the latter is a visit to the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Co.

Although all plans have not yet been completed, a tentative program has been prepared. This lists the following papers: Survey of Lightning Disturbances on a Distribution System, by M. McClaren; Symposium on Reactors, by N. L. Pollard; Breakdown of Cable Insulation, by J. L. Haydon; Surges on Transmission Systems, by J. Slepian and J. F. Peters; Third Class Conductors and Mechanism of the Arcing Ground, by C. P. Steinmetz; Systems Transmitting Generated Voltage, by P. H. Chase; Systems Transmitting Transformed Voltage, by E. C. Stone; Value of Resistance in Grounded Neutral, by H. H. Dewey; Relay System of Duquesne Light Co. 66-kv. Ring, by H. P. Sleeper; Ground Selector Relay Scheme, by P. Ackerman; Symposium on Electric Furnace Design and Operation Under Leadership of J. L. Yardley; Symposium on Radio Developments.

David Augustus Decrow

DAVID AUGUSTUS DECROW died in East Orange on Thursday, Feb. 15, and was buried in Lockport, N. Y., Sunday, the 18th.

Born in Bangor, Me., a descendant of Vere Royce, a distinguished New England civil engineer, from whom Mt. Royce received its name, he was graduated from Maine State College of Mechanic Arts of the University of Maine at Orona, in the class of 1879, and was always proud to claim a connection with that state.

After graduation from college, Mr. Decrow taught school for a year or more in a lumber camp in Maine, but was forced to give up that work due to lack of funds in the school board treasury.

He went from Maine to Lockport in the early '80s and became associated with the Holly Mfg. Co. as a mechanical draftsman. Here his engineering and business ability was evident from the start and his promotions with the Holly Co. were rapid. In 1893 he was made designing engineer, in 1900 chief engineer and in 1903 secretary of the Holly Mfg. Co. During his connection with that plant, he became known as a waterworks engineer of national prominence and continued his work as a specialist in that line to the time of his death.

Mr. Decrow designed and installed waterworks pumping machinery for many of the largest cities in the United States, among the most prominent of which are Buffalo, N. Y., Detroit, Mich.; St. Louis, Mo.; Columbus, O.; Cincinnati, O.; Louisville, Ky.; Boston, Mass.; Cleveland, O., and Philadelphia, Pa.

Some years ago, the Holly Mfg. Co. was combined with the Snow Steam Pump Works at Buffalo, N. Y., as part of the International Steam Pump Co. Mr. Decrow came to Buffalo at the time of this change and took charge of the pumping machinery manufactured by both companies.

In April, 1916, the International Steam Pump Co. was succeeded by the Worthington Pump and Machinery Corporation, and soon thereafter Mr. Decrow was called to the head office in New York as manager of of the Waterworks Department, in which position he continued until his untimely death. It is significant that he remained with what was to all intents and purposes the same organization from the time he began his professional work until the close of a most successful career.

Mr. Decrow was active in the affairs of the American Society of Mechanical Engineers and chairman of the Committee for the Revision of Test Code for Reciprocating Displacement Pumps. He had been president of the Buffalo Club, president of the Park Club at Buffalo, member of the Buffalo Consistory and Ismailia Temple of the Mystic Shrine and Beta Theta Pi College Fraternity.

He had a very wide acquaintance and has left behind him a record of constructive professional accomplishments which will serve as an inspiration to those who follow him.

He is survived by his wife and two sons.

H. H. Stoek Dies on March 1

DR. H. H. STOEK, head of the mining department of the University of Illinois, died instantly of heart failure on March 1 at Urbana, Ill. While Dr. Stoek was known nationally for his untiring efforts in furthering the industries of mining and metallurgy, he was also well known to the power plant field for his extensive work on the problem of storing coal.

Dr. Stoek was born in Washington, D. C., Jan. 16, 1866, and received his early education in the schools of that city. In 1887 he was graduated from Lehigh University and in 1888 received the degree of engineer of mines after a year of graduate work. He held important positions in government service, industrial work and educational endeavor, during the course of his career. From 1898 to 1909, he was managing editor of Mines and Minerals, which gave him an intimate knowledge of mining work in practically all fields. From 1909 to the time of his death, he was professor of mining engineering at the University of Illinois and also acted as head of the department.

In his study of the subject of coal storage, he wrote many bulletins and articles on methods and the economies of such work. As a member of the Federal Coal Commission, he also contributed a report on coal storage and, in fact, he was recognized as a leading authority on the subject.

News Notes

J. F. BORELAND, vice-president of the Huhn Mfg. Co., New York City, is at the present time taking an extended trip to Japan and Hawaii to look after the company business and appoint distributors for the sale and distribution of Huhn packing.

HENRY F. RUSSELL, formerly with Lumen Bearing Co., and for the last 5 yr. sales manager of the iron foundry department of Farrar and Trefts, Inc., Buffalo, has been appointed treasurer and general manager of the Buffalo Smelting Co., Inc., Buffalo.

THE WEBSTER MFG. CO. of Chicago, Ill., and Tiffin, Ohio, announces further expansion in connection with its Canadian business; a new corporation has been arranged —the Webster-Inglis, Ltd., 14 Strachan Ave., Toronto. The facilities of this plant will enable it to design and manufacture high grade elevating, conveying and power transmission machinery, along the same lines as now manufactured by the Webster Mfg. Co.

EDWARD H. STEHMAN, formerly of the engineering department of the Bacharach Industrial Instrument Co., has opened an office at 53 W. Jackson Blvd., Chicago, where he will represent this company, handling all of its products, and in addition will handle one product of Herman H. Stecht & Co., New York, the Megohmer, an instrument for testing insulation resistance.

THE GIRTANNER ENGINEERING CORPORATION, formerly of 1400 Broadway, New York City, has been made subsidiary of the American Brake Shoe & Foundry Co. and will enlarge its activities of manufacturing and installing standardized steam ash and soot removal system and other boiler house equipment. Offices have been removed to 30 Church St., New York City, and agencies are to be established in all leading cities.

P. I. ROBINSON, formerly manager of the Fort Madison (Iowa) Electric Co., has been appointed manager of the Baton Rouge (La.) Electric Co. Mr. Robinson is succeeded at Fort Madison by Walter M. Bird, formerly railway superintendent of the Savannah Electric & Power Co., of Savannah, Ga. The properties involved in the changes are under the management of Stone & Webster, Inc., of Boston.

CLAYTON W. PIKE, former chief of the electrical bureau of Philadelphia, has been called to Baltimore to make a survey of the city's underground electric conduit system and map out a policy of future development of that system to coincide with the expected and anticipated growth of that city and of sections not now embraced in the conduits.

PENNSYLVANIA EDISON CO. at Easton, Pa., is installing an automobile transmission between an alternating current motor and a Westinghouse stoker. A three-point type controller and resistance facilitates operation. The transmission is mounted on a base and it is direct connected through a coupling to the motor. A Morse chain drive transmits the power from the line shaft to the speed shaft.

ACCORDING TO Vice-Consul H. S. Tewell, the Hollinger Consolidated Gold Mines, Ltd., has now definitely arranged with the provincial government of Ontario for the power rights at Island Falls on the Abitibi River. The estimated cost of the plant, including the transmission lines, is between three and four million dollars.

FIRING BOILERS in Industrial Plants and Power Plants with Pulverized Coal was the subject of a lecture by Fred. L. Scheffler of the Fuller Engineering Co., New York City, at the Brooklyn Engineers' Club on Feb. 15. Slides showing the entire process of coal handling with this system were shown. The speaker pointed out the great field for this process in reclaiming fuels not otherwise available, such as the graphite coal of Rhode Island, culm, and river coal, and its extension in recent years through the development of furnaces with great combustion space. The latest figures, he said, show that 15,000,000 T. of pulverized coal are used annually in this country. By no means all of this is consumed in power furnaces, however, as 50 per cent of it is claimed by the cement industry. The pulverizing process divides its product so finely that 85 per cent of it will go through a mesh having 40,000 holes to the square inch.

A MEETING of the Metropolitan Section of the A. S. M. E., at Newark, on Feb. 13, was addressed by Prof. M. A. Hunter of Rensselaer Polytechnic Institute on the subject, High Temperature Alloys. Presentation and discussion were informal. The principal alloys dealt with were those of nickel with copper chromium, and aluminum. The electrical properties of these alloys were particularly mentioned; but discussion centered on their availability for certain other uses, such as valve parts and springs and boiler tubes, in which service would subject them to high temperatures and high pressures.

PURCHASE OF nearly $250,000 worth of electric equipment is expected to be made by the Board of City Directors of Pasadena, Cal., at the next meeting, bids having been received for the new 10,000 kw. steam turbine plant to be built by that city. The plant will be ready probably within 10 mo., that length of time being required to construct the equipment and machinery, put up the building, and make installations. There were three bids received as follows: Westinghouse Electric and Manufacturing Co., $188,350; Allis-Chalmers Manufacturing Co., $194,215; General Electric Co., $197,170.

DRAVO-DOYLE CO., of Philadelphia, was awarded the contract to install a turbo generator and switchboard in the city pumping station, Allentown, Pa., at a bid of $4313. Resellaer Valve Co. is to furnish the valves and fire hydrants, oil is to be from the Texas Co., for lubricating purposes; while the iron water pipes, etc., are to be supplied by the Donaldson Iron Co.

THE PUBLIC UTILITIES operating in Lancaster, Pa., are to place their service wires, mains, etc., in underground conduits, in the central portion of the city.

Catalog Notes

GILLIS AND GEOGHEGAN, 558 West Broadway, New York, has just issued a pamphlet No. 280, which illustrates and describes the equipment used with the G & G Telescopic Hoist to save labor and make the hoistway safe.

HARDINGE CONICAL MILLS are described in bulletin No. 13 recently published by the Hardinge Co., of New York City. The bulletin goes into the theory of grinding in mills of this type and shows some of the applications, including the pulverizing of coal, for which the mills have been used.

BULLETIN No. 4C, describing the Koerting Venturi stack draft system, a new product of the Schutte & Koerting Co., Philadelphia, Pa., has recently been received. Two types of installation are dealt with: one in which the induced draft fan handles a portion of the flue gas as the "motive gas," and one in which fresh air is used for this purpose.

THE COMBUSTION ENGINEERING CORP. has just issued a bulletin describing the Combusco Water Level Ash Conveyor. This is a new type of conveyor in this country, although there have been a number of successful installations in Europe. By this system ash is conveyed directly from the furnace ash hopper to the storage bin or any desired point of discharge, by a scraper conveyor operating in a trough filled with water.